HICKLING

CA1
DTC 800
88
A17
c.2

89-04046/

Date Due

SEP 5 1989

BRODART, INC Cat No 23 233 Printed in U S A

FINAL REPORT

TP 9566E **December 1988**

ACCESSIBILITY OF SMALL AIRCRAFT TO DISABLED TRAVELLERS: PRELIMINARY DESIGN STUDY

Library and Information Centre / Centre de Documentation (CSL)
RECEIVED - REÇU LE
MAY 10 1989
Transport Canada / Transports Canada

Prepared for the:
Transportation Development Centre
Policy and Coordination Group,
Transport Canada

Prepared by:

Brian Guthrie and Peggy Campbell,
James F. Hickling Management Consultants Ltd.
Ottawa, Toronto, Montreal and Halifax

And:
Michel Gravel,
DELCAN Corporation
Offices Nation-Wide

In Association with:
Geoff Fernie,
Centre for Studies in Aging/
Sunnybrook Health Services Inc.
Toronto

HICKLING Ref: 2286

4 4322

DDN 4/13565

The contents of this report reflect the views of the authors and not necessarily the official views or opinions of the Transportation Development Centre of Transport Canada, or the members of the project review committee.

Un sommaire en français de ce rapport est inclus avant la Table des matières.

PROJECT TEAM

The project team included the following individuals:

James F. Hickling Management Consultants Ltd.

Dr. David Lewis, Partner-in-Charge
Mr. Brian Guthrie, Project Manager
Ms. Peggy Campbell

DELCAN Corporation

Mr. Michel Gravel
Mr. Don Stephens

Centre for Studies in Aging/Sunnybrook Health Services Inc.

Dr. Geoff Fernie
Mr. Kevin Lunau
Mr. Steven Reed

Transport Canada / Transports Canada

Development / Développement

REPORT DOCUMENTATION FORM

1. Transport Canada Report No.	2. TDC Project No.	3. Recipient's Catalogue No.
TP 9566E	6967	

4. Title and Subtitle	5. Report Date
Accessibility of Small Aircraft to Disabled Travellers: Preliminary Design Study	December 1988
	6. Performing Organization Report No. 2286

7. Author(s)	8. Transport Canada File No.
Brian Guthrie, Peggy Campbell, Geoff Fernie and Michel Gravel	D1450-103-83

9. Performing Organization Name and Address	10. DSS File No.
James F. Hickling Management Consultants Ltd. 350 Sparks Street, Suite 601 Ottawa, Ontario K1R 7S8	16SD.T8200-7-7526
	11. DSS or Transport Canada Contract No. T8200-7-7526/01-SD

12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
Transportation Development Centre (TDC) 200 Rene Lvesque Blvd. West West Tower, Suite 601 Montreal, Quebec H2Z 1X4	Final, October 1988
	14. Sponsoring Agency Code

15. Supplementary Notes	16. TDC Project Officer
	Barbara A. Smith

17. Abstract

This work addresses the accessibility of small aircraft to disabled travellers in Canada. It assesses the difficulties encountered in boarding the aircraft and transferring to the aircraft seat, suggests conceptual solutions to these difficulties, and provides a framework for evaluating the solutions. Particular emphasis is given to wheelchair users and the level change from tarmac to aircraft floor.

The current situation is reviewed. Several factors demonstrate the need for innovative new concepts. These factors include the physical dimensions and configurations of the various small aircraft, and the lack of appropriate lift equipment and boarding procedures. A review of market numbers shows that the elimination of these barriers could increase current ridership in Canada by tenfold.

A framework for evaluating alternative design solutions is developed. Several factors are emphasized: (i) integration with the flow of able-bodied traffic; (ii) minimal transfers for wheelchair users; (iii) protection from weather; (iv) negligible modification of the aircraft; and, (v) design simplicity, ease of operation and low cost.

Several generic concepts are developed and evaluated using the framework. Two are recommended for detailed design and prototyping: (i) a low level loading bridge (modelled after existing jet-ways) and (ii) an integrated platform lift and stairway.

18. Key Words	19. Distribution Statement
Air Transportation, Accessibility, Commuter Aircraft, Disabled Travellers, Level Chang Devices	Limited number of copies available from the Transportation Development Centre

20. Security Classification (of this report)	21. Security Classification (of this page)	22. No. of Pages	23. Price
Unclassified	Unclassified	75	Nil

Canada

Transports Canada / Transport Canada

Développement / Development

FORMULE DOCUMENTAIRE DU RAPPORT

1. N° du rapport Transports Canada	2. N° de l'étude — CDT	3. N° de catalogue du destinataire
TP 9566E	6967	

4. Titre et sous-titre	5. Date du rapport
Accessibility of Small Aircraft to Disabled Travellers: A Preliminary Design Study	Décembre 1988
	6. N° du rapport de l'organisme exécutant: 2286
7. Auteur(s)	8. N° de dossier Transports Canada
Brian Guthrie, Peggy Campbell, Geoff Fernie, Michel Gravel	D1450-103-83
9. Nom et adresse de l'organisme exécutant	10. N° de dossier — ASC
James F. Hickling Management Consultants Ltd. **350 Sparks Street, Suite 601** **Ottawa, Ontario** **K1R 7S8**	16SD.T8200-7-7526/01-SD
	11. N° de contrat — ASC ou Transports Canada
12. Nom et adresse de l'organisme parrain	13. Genre de rapport et période visée
Centre de developpement des transports (CDT) **200 ouest, boul. René-Lévesque** **Tour Ouest, Suite 601** **Montreal, Québec H2Z 1X4**	Final, Octobre 1988
	14. Code de l'organisme parrain
15. Remarques additionnelles	16. Agent de projet — CDT
	Barbara A. Smith

17. Résumé

La présente étude a pour objet l'accessibilité des transports aériens par petits porteurs aux personnes handicapées. Elle examine les difficultés inhérentes à l'embarquement et au transfert, dans les fauteuils de l'appareil, de cette catégorie de passagers. Elle suggère des solutions à ces problèmes, ainsi qu'une grille d'évaluation des solutions proposées. Elle s'attache particulièrement à la difficulté que représente, pour les passagers en fauteuil roulant, le déplacement vertical depuis l'aire de trafic jusqu'au plancher de la cabine.

Un examen de la situation actuelle dans les transports par petits porteurs a établi la nécessité de trouver des solutions nouvelles aux problèmes considérés. En effet, les dimensions et la configuration des divers modèles d'appareils en exploitation entravent le déplacement des personnes handicapées; par ailleurs, le aéroports sont souvent dépourvus d'équipements et de techniques d'embarquement adaptés. Une étude du marché indique que si ces obstacles tombaient, le nombre de pas sagers handicapés pourrait être décuplé.

Une grille d'évaluation a été élaborée pour juger les diverses solutions proposées. Les principaux critères d'évaluation sont les suivants: (i) aucun obstacle à la circulation des autres passagers; (ii) minimum de transferts d'un fauteuil à l'autre; (iii) protection contre les intempéries; (iv) minimum de modifications à apporter à l'appareil; (v) simplicité du concept, facilité d'exploitation et coût minimal.

Plusieurs concepts ont été évalués à l'aide de cette grille. Deux d'entre eux ont été retenus en vue d'un projet de prototype. Il s'agit d'une passerelle d'embarquement, conçue sur le modèle de passerelles pour gros porteurs, et d'un escalier mobile avec plate-forme élévatrice intégrée.

18. Mots-clés	19. Diffusion
Transports aériens, accessibilité, petits porteurs, passagers handicapés, dispositifs d'embarquement adaptés.	**Le Centre de développement des transports dispose d'un nombre limité d'exemplaires.**

20. Classification de sécurité (de ce rapport)	21. Classification de sécurité (de cette page)	22. Nombre de pages	23. Prix
Non classifiée	Non classifiée	75	Aucun

CDT/TDC 79-005 Rev 86

Canada

ACKNOWLEDGEMENTS

The project team is grateful to the project review committee for its input and guidance. The committee members were:

Barbara A. Smith	Transportation Development Centre, Policy and Coordination Group, Transport Canada, Montreal (Project Officer)
Valerie Dufour	Transport Canada, Ottawa
Frank Hare	Transport Canada, Ottawa
Linda Landry	National Transportation Agency, Ottawa
Stuart Grant	Air Transportation Association of Canada, Ottawa
Stephen Little	(Ontario) Office for Disabled Persons, Toronto
Ellis Reida	NINNESCAH Magazine, New York
Diana Kirkpatrick	(U.S.) Regional Airline Association, Washington D.C.

A special thanks goes to the deHavilland Aircraft Company of Canada, especially Ron Jackson, Jack Swann, David Schenck and Charles Lau, for their hospitality and input during the second "knowledge circle" meeting.

GLOSSARY

Airstairs: Aircraft access stairs that are built as an integral part of the cabin door, functioning when the door is opened.

CHDS: Canadian Health and Disability Survey, performed by Statistics Canada in 1983/84.

Commuter aircraft: See Small aircraft.

Ground side equipment: Aircraft and air carrier servicing equipment operating on the tarmac at an airport.

Interlining: Transfer from one airline to another during a journey.

Level change device: Any mechanical or electromechanical device used to physically move passengers from one horizontal plane to another.

Mobility impaired: Those persons who have difficulty walking distances, climbing stairs, etc. (as defined in several functional terms by the CHDS); Includes wheelchair users and those less severely disabled.

Small aircraft: For the purposes of this report, those aircraft able to seat 60 passengers or less.

EXECUTIVE SUMMARY

This report addresses the accessibility of small, commuter aircraft to disabled travellers. The primary focus of the work is the ability of wheelchair users to board the aircraft and transfer to the aircraft seat.

Background: Several factors indicate that the use of small aircraft will increase dramatically in coming years. Recent mergers of Canadian air carriers have resulted in a national structure characterized by a network of "hubs" and "spokes". Hubs are major destinations served primarily by large aircraft. Spokes are feeder or collector routes, served by smaller aircraft. In addition, there are the commuter services serving large centres with small aircraft.

Small aircraft in Canada are generally operated by small carriers, often out of small airports. Thus, complex and expensive boarding equipment is not available, nor is it cost-effective.

User Characteristics and Market: Mobility impaired travellers[1] encounter difficulties at all stages of a small aircraft journey, including boarding and disembarking, moving about in the terminal, and on-board seating. The level change (from tarmac to aircraft floor) is the most obvious barrier to wheelchair users. However, wheelchair users are only a small proportion of the mobility impaired population. For the less severely disabled and the frail elderly, the walking distances can be prohibitive. Solutions should therefore address the broadest range of mobility disabilities.

The current ridership on small Canadian aircraft is estimated at 13 wheelchair passengers per week (across the country) and 300 other mobility impaired passengers per week. With the development of appropriate assistive devices and the elimination of other barriers (such as income and employment), ridership could be increased by more than tenfold, to 300 wheelchair passengers per week and 4,000 other mobility impaired passengers per week. (This is the "barrier-free" model.)

Personal Mobility Aids: Storage of mobility aids is a major concern in air travel, and especially problematic in commuter aircraft. In the smallest aircraft, storage of wheelchairs is physically impossible. In the twenty-seaters, luggage must be carefully arranged for fit and centre of gravity, prompting many carriers to request advance notice. The potential for storage problems becomes more acute during interlining, when a traveller transfers to a small aircraft.

---

1 Mobility impaired persons are those who have difficulty moving about, walking distances, climbing stairs, etc. The group can include: people using wheelchairs, walkers, crutches, canes, etc.; those with respiratory ailments; the frail elderly; etc.

Specialized boarding chairs have been developed for use in large aircraft, but are too wide for the typical commuter aircraft aisle. A new chair must be developed. Ideally this chair would serve the user for his/her movement from the airport waiting room to aircraft seat, reducing the number of transfers required.

The timing of the transfer from the individual's wheelchair into the carrier's specialized chair is critical. Passengers prefer to transfer as late as possible in the process (for comfort); airlines prefer the transfer as early as possible (to facilitate storage of the passenger's wheelchair).

Aircraft Characteristics: There are a number of different small aircraft operating across Canada, with a variety of physical barriers to disabled users. The primary challenges include: the air-stairs (including supports), door widths, vestibule configurations (i.e. turning a wheelchair inside the aircraft), aisle widths, and the armrests on seats.

Six small aircraft expected to be in common use within the next five years are representative of the above critical factors. They are the Cessna 402, Dash 8, Twin Otter, Convair 580, Jetstream 31 and Metroliner III.

Current Practice: Small aircraft are often parked away from the terminal building and at "the far end", causing a long and difficult walk or ride for mobility impaired travellers. The smaller Canadian carriers currently use whatever means available to board wheelchair travellers. This includes manual lifting, a forklift and pallet, or the high-backed wheelchair used in large aircraft. At small airports availability of personnel is limited, and it is often the ticket agent or pilot who assists the passenger. The safety of some of these boarding procedures is a real concern. At times service is even refused.

The issues of designated seating for, and quotas of, disabled passengers aboard aircraft are unresolved. The real safety implications are not clear. In practice, it is a judgement call by the carrier.

There are several lifts and level-change devices on the market, some built for large aircraft. None of these is appropriate for commuter aircraft. However, at least one U.S. and two Canadian manufacturers are developing prototypes. In addition, the U.S. Federal Aviation Administration (FAA) has a program underway to sponsor the development of a level change system for aircraft.

A Design Evaluation Framework: The major objectives influencing the design of an accessible system for small aircraft are summarized as follows:

- Minimize transfers. Integrate a specialized, on-board wheelchair into the concept;
- Facilitate wheelchair storage;
- Account for weather (especially ice, packed snow and cold);
- Provide for the free flow of all passengers. Facilitate, rather than inhibit, the flow of able-bodied travellers;
- Ensure negligible modifications to the actual aircraft;
- Ensure simplicity of design and operation;

- o Consider different solutions for different airport sizes. Consider variations in budgets, staff and existing equipment; and,
- o Consider the capital cost, especially the constraints of the smaller carriers.

These and other factors have been synthesized into an evaluation framework. The factors are defined in terms of specific criteria, and are grouped according to: safety, functional adequacy (operations, portability, climate, etc.), technical requirements (standards, dimensions, design life, maintenance, etc.), and passenger comfort. Each criterion has a "minimum acceptable" and an "ideal". A weighing and scoring system is applied to ensure all factors are considered, and to allow for comparison of design concepts.

The Preferred Concepts: The project team developed and evaluated several concepts and variations. The two concepts of greatest potential are a "low-level loading bridge" and a "platform lift". Both are simple, easy to operate, and enhance, rather than impede, the flow of **all** passenger traffic. They are compatible with all of the small aircraft currently used in Canada.

The loading bridge is based on the jet-way concept and is shown in Figure 1. It involves the use of semi-permanent ramps or walkways extending from the terminal into the centre of the aircraft parking area. The walkways are built in simple sections, possibly with weather covers. The end sections are movable such that they may be pivoted (horizontally or vertically) to butt up against various aircraft. Manual operation is quite feasible. Interference with ground-side traffic is one potential drawback.

The platform lift concepts employ a portable stairway system with an integrated lift. Two of the developed concepts are shown in Figures 2 and 3. The wheelchair traveller uses the lift to get to the aircraft door height. Able-bodied passengers then board via stairs, which are part of the device, without a need to move the device. The lift can be powered by a manual scissor jack, an existing forklift or comparable means.

Both concepts assume the use of a specialized boarding chair, developed in tandem with the concepts. The specialized boarding chair is shown in Figure 4. The chair is meant to be used on the level change device, in the aircraft aisle to the passenger's seat, thus minimizing transfers.

Next Steps: The recommended future work is as follows:

- o Functional design of the two selected concepts;
- o Selection of one concept for detailed design using the evaluation framework developed in this study;
- o Review of the market and costs of the specialized boarding chair;
- o Functional design of the boarding chair;
- o Fabrication of prototypes; and,
- o Evaluation of the prototypes at airports of varying sizes.

This work should include consultation with: Canadian airports, small carriers and the U.S. Federal Aviation Administration which is running a parallel program.

SOMMAIRE

Le présent rapport traite de l'accessibilité des transports aériens par petits porteurs aux personnes à mobilité réduite et, en particulier, à celles qui se déplacent en fauteuil roulant.

Mise en contexte: Certains indices laissent présager que le nombre de petits porteurs utilisés dans les transports aériens, au Canada, augmentera de façon considérable au cours des prochaines années. De récentes fusions de transporteurs ont modifié la trame du réseau national de transport aérien; la liaison entre les principaux points de convergence est assurée surtout par des gros porteurs, tandis que le transport de rabattement est assuré par des petits porteurs, et le transport régional, uniquement par des petits porteurs.

Au Canada, les petits porteurs, généralement exploités par petites entreprises de transport, desservent surtout de petits aéroports qui ne sont pas équipés de matériels d'embarquement complexes et coûteux et où, de toute façon, leur achat ne saurait se justifier.

Besoins des usagers et marché potentiel: Pour les personnes à mobilité réduite,[2] les déplacements en petits porteurs présentent des obstacles à toutes les étapes du trajet: déplacement dans l'aérogare, embarquement, déplacement à bord de l'appareil et débarquement. Pour celles qui se déplacent en feuteuil roulant, la difficulté majeure est évidement le déplacement vertical pour passer de l'aire de trafic au plancher de la cabine de l'appareil. Quant aux usagers qui ont de la difficulté à marcher, comme les personnes âgées, cela peut être la distance à franchir pour se rendre jusqu'à l'appareil. Il faudrait donc que la solution recherchée tienne compte des besoins du plus grand nombre possible de passagers handicapés.

A l'heure actuelle, au Canada, les petits porteurs assurent chaque semaine le transport d'environ 13 personnes en fauteuil roulant et 300 autres utilisant d'autres formes d'aides à la motricité. La mise au point d'équipements d'embarquement adaptés et la suppression d'obstacles d'un autre ordre (ceux liés à l'emploi et au revenu, par exemple) permettraient de décupler, et peut-être davantage, le nombre de passagers de cette catégorie; vraisemblablement, les chiffres de 300 personnes en fauteuil roulant et 4000 autres utilisant d'autres formes d'aides à la motricité pourraient être atteints. (Il s'agit ici du scénario des aménagements dits "sans obstacle".)

Aides personnelles à la motricité: Le rangement à bord de l'appareil des aides à la motricité des passagers handicapés pose un problème de taille, en particulier

---

[2] Les personnes dites à mobilité réduite sont celles qui ont de la difficulté à se déplacer, à marcher sur de longues distances, à monter les escaliers, etc. Il peut s'agir de personnes se déplaçant à l'aide de fauteuil roulant, de déambulateur, de béquilles, de canne, ou encore de personnes atteintes de troubles respiratoires, de personnes âgées, etc.

lorsqu'il s'agit de petits appareils de transport régional. Dans les plus petits appareils, par exemple, il est impossible de loger un fauteuil roulant. Dans les appareils de 20 places, les bagages doivent être rangés sans perte d'espace et répartis en fonction du centre de gravité. C'est pourquoi les compagnies aériennes demandent souvent à être avisées au préiable du transport de personnes handicapées. Le problème du rangement des aides à la motricité risque de se poser de façon encore plus aigeë lorsque le passager handicapé de l'aérogare jusqu'à sa place à bord de l'appareil sans autre transfert.

Des fauteuils roulants spécialement dimensionnés ont été conçus pour usage à bord des gros porteurs; toutefois, étant trop larges pour les allées des petits appareils de transport régional de modèles courants, il faudrait en étudier un spécial. L'idéal serait un fauteuil qui permettrait de transporter le passager handicapé de l'aérogare jusqu'à sa place à bord de l'appareil sans autre transfert.

Le choix du moment où le passager handicapé doit être transféré de son propre fauteuil au fauteuil d'embarquement est critique. Pour des raisons de confort, ce passager préfère que le transfert se fasse le moins longtemps possible avant l'embarquement; par contre, le personnel préfère qu'il se fasse le plus tôt possible, à fin de pouvoir ranger le fauteuil du passager plus aisément.

Caractéristiques des porteurs: Il existe de nombreux modèles de petits porteurs en exploitation au Canada. Ils ne présentent pas tous les mêmes obstacles pour les personnes handicapées; toutefois, les plus courants sont: les escaliers d'embarquement (y compris leurs supports), la largeur de la porte de l'appareil, la configuration du vestibule (qui ne permet pas toujours de tourner en fauteuil roulant), la largeur de l'allée et les accoudoirs des fauteuils de l'appareil.

D'ici cinq ans, six petits porteurs, présentant les obstacles énumérés ci-dessus, seront vraisemblablement très répandus; ce sont: le Cessna 402, le Dash 8, le Twin Otter, le Convair 580, le Jetstream 31 et le Metroliner III.

Pratiques actuelles: Il arrive souvent que les petits porteurs soient stationnés en bout d'aire de trafic, donc à bonne distance de l'aérogare. Dans ces conditions, les passagers à mobilité réduite peuvent avoir de la difficulté à se rendre jusqu'à l'appareil. Présentement, les petites compagnies aériennes utilisent des moyens de fortune pour embarquer les passagers en fauteuil roulant: la force des bras, une palette et un chariot élévateur ou un fauteuil adapté conçu pour usage à bord des gros porteurs. Dans les petits aéroports, le personnel étant réduit, c'est souvent le pilote, ou let préposé aux billets, qui aide le passager handicapé à monter à bord. Certaines pratiques d'embarquement posent un réel problème de sécurité. Il arrive même qu'on refuse d'aider un passager handicapé à embarquer.

La question de l'assignation de places aux personnes handicapées et la limitation de leur nombre restent en suspens, les problèmes de sécurité y afférents n'étant pas bien définis. A l'heure actuelle, chaque transporteur se fie à son propre jugement.

Il existe sur le marché divers équipements de transport vertical, dont certains été conçus spécialement pour les gros porteurs, mais aucun d'entre eux ne convient à l'application envisagée. Toutefois, au moins un constructeur américain et deux constructeurs canadiens travaillent actuellement à la mise au point de prototypes adaptés. De plus, la U.S. Federal Aviation Administration (FAA) subventionne des

travaux de recherche et de développement visant la réalisation de dispositifs élévateurs pour l'embarquement.

Grille d'évaluation des solutions proposées: Le dispositif recherché devra être conçu en fonction des principaux objectifs définis ci-dessous, soit:

- Réduire au minimum les transferts d'un fauteuil à l'autre. Le dispositif devra prévoir un fauteuil de bord spécialement adapté.

- Faciliter le rangement des faueuils des passagers à bord de l'appareil.

- Tenir compte des dangers liés aux conditions atmosphériques (verglas, neige durcie, froid).

- Garantir la circulation sans obstacle de tous les passagers.

- Ne nécessiter que de légères modifications du porteur.

- Etre de conception simple et d'exploitation facile.

- Envisager diverses solutions en fonction de l'importance des différents aéroports. Prendre en considération les moyens financiers, le personnel disponible et l'équipement en place.

- Tenir compte de l'investissement requis pour la mise en oeuvre du dispositif, en pensant surtout aux petites compagnies aériennes.

Ces critères de conception, et d'autres encore, ont permis d'élaborer une grille d'évaluation devant servir à juger les divers concepts présentés, en fonction de la sécurité, de l'aptitude à remplir la fonction définie (conditions d'exploitation, mobilité, climat, etc.), des caractéristiques techniques (conformité aux normes, dimensions, durée de vie utile, entretien, etc.) et du confort des passagers. Une cote allant du "minimum acceptable" à l' "idéal" est attribuée pour chaque critère d'évaluation. Un système de notation et de pondération permet de s'assurer que tous les critères de conception ont été pris en compte et de comparer les divers concepts présentés.

Concepts retenus: L'équipe a élaboré et évalué plusieurs concepts de base et des variantes. Les deux concepts jugés les plus prometeurs sont une passerelle et un dispositif à plate-forme élévatrice. Ces deux équipements sont simples, faciles à utiliser et permettraient d'améliorer la circulation de l'ensemble des passagers. De plus, ils sont compatibles avec tous les modèles de petits porteurs actuellement en exploitation au Canada.

La passerelle, conçue sur le modèle des passerelles pour gros porteurs est illustrée à la figure 1. Il s'agit de plans inclinés ou de trottoirs semi-permanents, couverts ou non, qui partiraient de l'aérogare et s'avanceraient jusqu'au milieu de l'aire de trafic. Ils seraient construits par sections, celle du bout étant articulée de manière à pouvoir être placée devant la porte des divers appareils. Cette passerelle pourrait être manoeuvrée manuellement. Un inconvénient possible est qu'elle risque de gêner la circulation sur l'aire trafic.

Le dispositif à plate-forme élévatrice est constitué d'un escalier mobile avec plateforme intégrée. Deux des modèles élaborés sont illustrés aux figures 2 et 3. Les passagers en fauteuil roulant seraient embarqués les premiers à l'aide de la plateforme élévatrice; les autres passagers pourraient ensuite emprunter l'escalier sans qu'il soit besoin de retirer la plate-forme. Cette dernière pourrait être manoeuvrée par un cric à pantographe, un chariot élévateur emprunté au matériel aéroportuaire ou un autre moyen analogue.

Les deux modèles illustrés du dispositif à plate-forme élévatrice exigent un fauteuil d'embarquement spécialement conçu, comme celui présenté à la figure 4. Ce fauteuil servirait à transporter le passager handicapé du niveau du sol jusqu'à sa place à bord de l'appareil, sans autre transfert requis.

Prochaines étapes: Les travaux devraient être poursuivis dans le sens défini ci-dessous:

- Étude fonctionnelle des deux concepts retenus.
- Choix du concept qui sera réalisé en prototype guidé par la grille d'évaluation élaborée dans le cadre de la présente étude.
- Évaluation du coût de production du fauteuil adapté et étude de marché.
- Étude fonctionnelle du fauteuil adapté
- Construction de prototypes.
- Évaluation des prototypes en service dans des aéroports de différente envergure.

Ces travaux devraient être poursuivis en consultation avec des aéroports canadiens, des petits transporteurs canadiens et la U.S. Federal Aviation Administration, laquelle mène des travaux parallèles à ceux proposés.

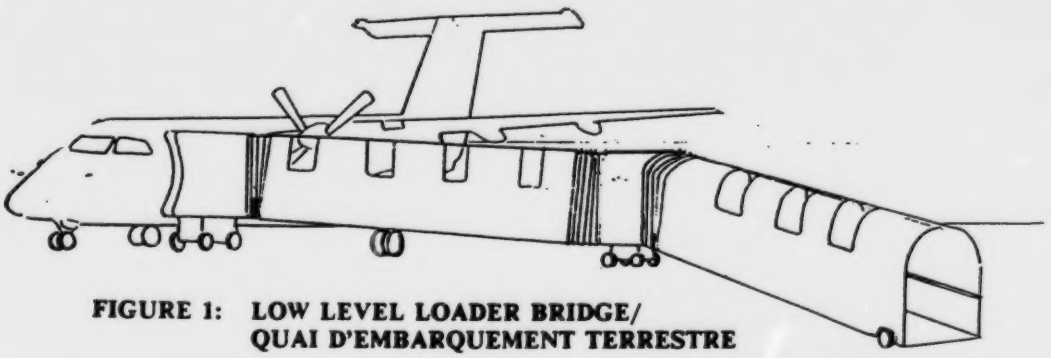


**FIGURE 1: LOW LEVEL LOADER BRIDGE/
QUAI D'EMBARQUEMENT TERRESTRE**

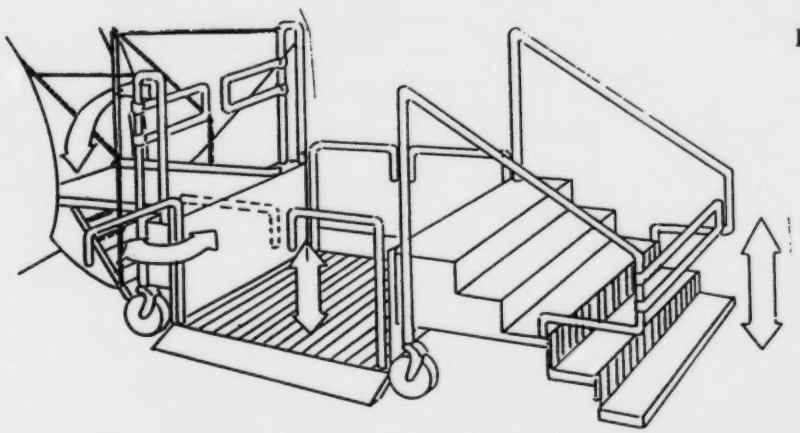


**FIGURE 2: PLATFORM LIFT
CENTRAL/
ASCENSEUR CENTRAL**

**FIGURE 3: PLATFORM LIFT
STAIRGLIDE/
PLATEAU MONTANT
SUIVANT L'ESCALIER**

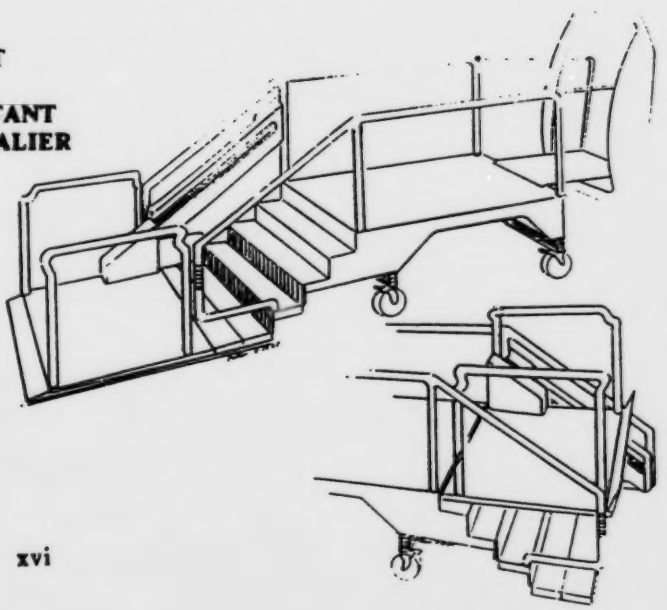
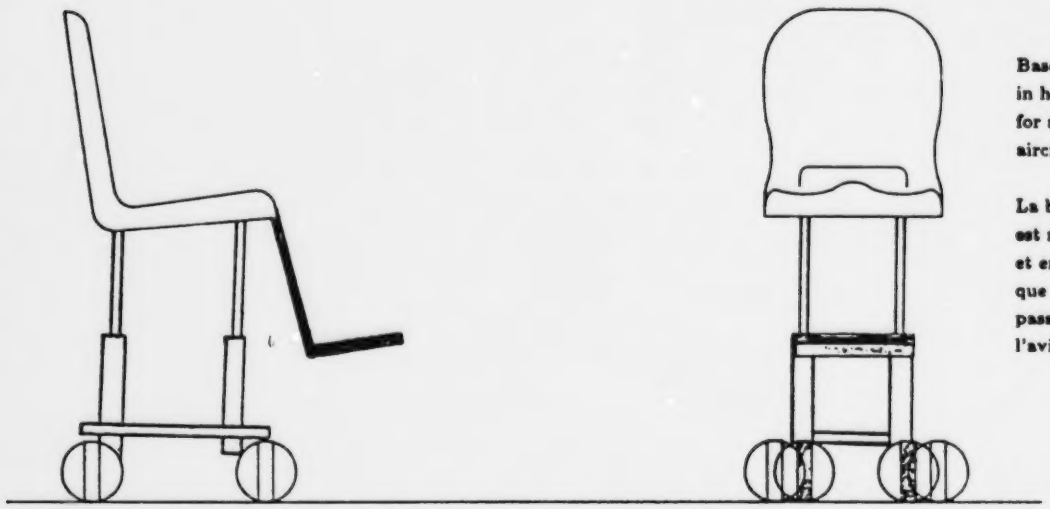
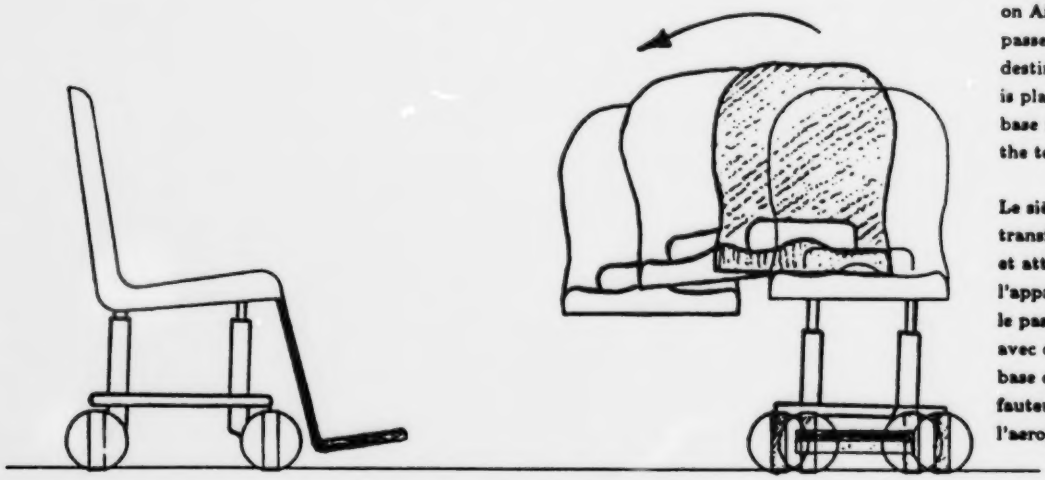


FIGURE 4: SPECIALIZED BOARDING CHAIR/
FAUTEUIL D'EMBARQUEMENT SPÉCIALEMENT



Base is adjustable in height and width for access through aircraft aisle.

La base du fauteuil est réglable en hauteur et en largeur, de sorte que le fauteuil puisse passer dans l'allée de l'avion.



Seat is removed with occupant and strapped on Aircraft seat - passenger travels to destination where seat is placed back on a base and wheeled to the terminal.

Le siège amovible est transféré avec le passager et attaché au fauteuil de l'appareil. A l'arrivée, le passager est transfére avec cesiège sur une autre base et transporté dans ce fauteuil reconstitué jusqu'à l'aerogare.

Shoulder and lap belts not shown for clarity.

Pour ne pas nuire à clarté du schéma, les ceintures de sécurité ne sont pas illustrées.

TABLE OF CONTENTS

CHAPTER 1: INTRODUCTION 1
- 1.1 AN OVERVIEW OF THE NEED 1
- 1.2 OBJECTIVES AND SCOPE 2
- 1.3 SUMMARY OF ACTIVITIES 2
- 1.4 PLAN OF REPORT 3

CHAPTER 2: THE CURRENT SITUATION 4
- 2.1 USER CHARACTERISTICS 4
- 2.2 AIRCRAFT TYPES 10
- 2.3 PERSONAL MOBILITY AIDS 15
- 2.4 CARRIER AND AIRPORT PROCEDURES 21
- 2.5 LEVEL CHANGE DEVICES 24

CHAPTER 3: INFLUENCING FACTORS AND DESIGN CRITERIA 28
- 3.1 INFLUENCING FACTORS 28
- 3.2 DESIGN CRITERIA 33

CHAPTER 4: CONCEPTUAL DESIGNS 38
- 4.1 LOADING BRIDGES 39
- 4.2 PLATFORM LIFTS 44
- 4.3 INDEPENDENT VEHICLES 51
- 4.4 SPECIALIZED BOARDING CHAIR 54
- 4.5 EVALUATION OF CONCEPTS 60

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS 62
- 5.1 THE OVERALL NEED 62
- 5.2 CONCLUSIONS FROM THE CONCEPT EVALUATIONS 64
- 5.3 RECOMMENDED APPROACH TO FUTURE WORK 64
- 5.4 OTHER FINDINGS OF SIGNIFICANCE 65

REFERENCES 66

APPENDIX A: Small Aircraft in Operation in Canada
APPENDIX B: Small Aircraft Fleets of Canadian Air Carriers
APPENDIX C: Selected Aircraft - Illustrations and Dimensional Data
APPENDIX D: Representative Wheelchair Dimensions
APPENDIX E: Boarding and In-Flight Chairs
APPENDIX F: Existing Level Change Equipment
APPENDIX G: Air Carrier and Airport Contacts
APPENDIX H: Conceptual Design Evaluation
APPENDIX I: Project Review Committee

FIGURES

FIGURE 2.1: AIR TRANSPORTATION IN CANADA: RELATIVE SIZES OF THE DISABILITY GROUPS 7
FIGURE 2.2: DIMENSIONAL DATA OF EXAMPLE BOARDING CHAIR . 20
FIGURE 4.1: LOW LEVEL LOADER - PARTIAL BRIDGE 41
FIGURE 4.2: LOW LEVEL LOADER - FULL BRIDGE 42
FIGURE 4.3: PORTABLE SWITCHBACK RAMP 43
FIGURE 4.4: CENTRAL ELEVATOR 46
FIGURE 4.5: CENTRAL ELEVATOR WITH ALL-WEATHER COVER . . . 47
FIGURE 4.6: ADJACENT ELEVATOR 48
FIGURE 4.7: STAIR GLIDE 49
FIGURE 4.8: STAIRAMP 50
FIGURE 4.9: MINI-SHUTTLE 52
FIGURE 4.10: FORKLIFT/PALLET 53
FIGURE 4.11: SPECIALIZED BOARDING CHAIR - VARIATION I 56
FIGURE 4.12: SPECIALIZED BOARDING CHAIR - VARIATION II 57
FIGURE 4.13: SPECIALIZED BOARDING CHAIR - VARIATION III 58
FIGURE 4.14: SPECIALIZED BOARDING CHAIR - VARIATION IV 59

TABLES

TABLE 2.1: POPULATION OF DISABLED PERSONS - AIR TRANSPORTATION 7
TABLE 2.2: ESTIMATED ANNUAL RIDERSHIP ON AIRLINES IN CANADA 8
TABLE 2.3: ESTIMATES OF CURRENT RIDERSHIP (1984) 9
TABLE 2.4: PRINCIPAL AIRCRAFT TYPES BY WEIGHT GROUP, USED BY LEVEL I-V AIRCARRIERS, 1970, 1985 . 11
TABLE 2.5: AIRCRAFT SELECTED FOR DETAILED ANALYSIS 13
TABLE 2.6: FIT OF BOARDING CHAIRS IN SMALL AIRCRAFT AISLES 19
TABLE 2.7: AVAILABLE LEVEL CHANGE DEVICES - COMPARISON CHART 26
TABLE 3.1: INFLUENCING FACTORS AND CONSTRAINTS 30
TABLE 3.2: SMALL AIRCRAFT ACCESSIBILITY DEVICE - DESIGN CRITERIA 35

CHAPTER 1: INTRODUCTION

1.1 AN OVERVIEW OF THE NEED

Recent mergers of Canadian air carriers have resulted in a national structure characterized by a network of "hubs" and "spokes". Hubs are major destinations served primarily by large aircraft belonging to the three prime carriers (Air Canada, Canadian Airlines International and Wardair). Spokes are feeder or collector routes, served by smaller aircraft belonging to small or subsidiary carriers[3]. In addition, there are independent airlines and commuter services such as City Express, utilizing small aircraft serving large, adjacent centres. These factors indicate that the use of small aircraft will, in all likelihood, increase in coming years.

Small aircraft in Canada are generally operated by small carriers, often out of small airports. Thus, complex and expensive boarding equipment is not available, nor is it appropriate. Carriers use whatever means available to board disabled passengers, including manual lifting by inexperienced personnel, or even refusal of service. Existing aircraft stairs are small and unwieldy. The aircraft themselves are often parked on the tarmac at one end of the terminal, resulting in a long walk for mobility impaired travellers.

The need to study the accessibility of small aircraft in Canada is affected by other considerations:

- An increasing social awareness of the special needs of disabled travellers;
- Recent American endeavors (technical and regulatory) in the field of accessible air transportation;
- The development of specialised equipment for larger aircraft (and other modes of transportation) and;
- The air industry is more constrained than land modes, on several fronts, including safety regulations, weight and space limitations, etc. Thus, specialists in the field are essential for full understanding of the implications of design and operating changes.

---

[3] In many cases, Air Canada and Canadian Airlines International own or are in partnership with the small carriers.

1.2 OBJECTIVES AND SCOPE

The specific objective of this work is to study the accessibility of small aircraft (less than 60 passenger capacity) in Canada, and to investigate changes to enhance the current situation. The primary focus is on the ability of mobility-impaired travellers[4] to make the trip from the waiting room to the aircraft seat. Of particular concern are the level change difficulties encountered by wheelchair users. Movement down the narrow aisle ways of the aircraft, and the storage of mobility aids (such as wheelchairs) are significant problems which are also addressed.

Improvements in the airport terminal are not in the scope of work. In-flight services (such as food and washrooms) are not considered as they are not significant issues on short flights.

The project involves the conceptualization of new methods, equipment and/or procedures. Both operational and technical barriers are considered. This is not a detailed design study, rather, it alludes to design concepts which should be pursued further. Recommendations and costs for subsequent work are provided.

1.3 SUMMARY OF ACTIVITIES

The principal activities of the project team were as follows.

- o A comprehensive review of the current situation, including:
  - Assessment of user characteristics and the Canadian market as a whole;
  - Review of current aircraft and their critical characteristics;
  - Consideration of wheelchairs, both the storage aspects and the need for a specialised boarding chair;
  - Review of current carrier and airport practices; and,
  - Listing of potentially relevant level change devices.
- o The synthesis results of the above review into influencing factors and design constraints:
  - Development of a pseudo-quantitative framework for the evaluation of design options;
  - Conceptualization of several preliminary designs;
  - Evaluation of the various designs and selection of several for further study; and,
  - Recommendations for further work, including associated costs.

---

[4] Mobility impaired persons are those who have difficulty moving about, walking distances, climbing stairs, etc. The group can include: those in wheelchairs; those using walkers, crutches, canes, etc.; those with respiratory ailments; the frail elderly; etc.

The development of new technologies in this field is a complex and challenging endeavour. Critical to technological development is an understanding of a thorough range of factors, including; user needs and characteristics, industrial design/ergonomics, mechanical engineering, manufacturing, transportation planning, constraints on service providers, social policy, etc. For this reason, the project team assembled a special advisory group which could simultaneously understand human barriers, consider technical constraints, and develop innovative concepts.

In addition to federal government participants, Transport Canada and the National Transportation Agency (NTA), the advisory group included individuals from DeHavilland Aircraft, the Air Transportation Association of Canada (ATAC), the U.S. Regional Airline Association (RAA), NINNESCAH, and the Ontario Office for Disabled Persons. The project team employed a structured framework in which the entire group could focus its innovative ideas, through high energy knowledge circles. Participation by all interested parties ensured that various perspectives to the problem and all possible solutions were considered.

Tasks such as the market assessment, review of current boarding methods and development of design criteria were first performed by the project team. It then identified constraints with the aid of the first knowledge circle.

The team then developed design criteria and "hit the drawing board". Several concepts were presented in the second knowledge circle in the form of illustrations, models and/or demonstrations. This knowledge circle meeting took place at DeHavilland, and included "walk-through" investigations. The concepts were discussed and expanded. New concepts were also generated by the group. The concepts were then refined and evaluated by the project team.

1.4 PLAN OF REPORT

The report is presented in five chapters. Chapter 1 outlines the need for the work, the objectives and the scope of the study. A summary of the activities undertaken in the project is also given. Chapter 2 presents an evaluation of the current situation, in terms of operational practices, user group demographics, available mobility aids and aircraft characteristics. Chapter 3 identifies the influencing factors and describes design criteria for evaluation of solutions. Chapter 4 presents the conceptual designs generated by the project team and project review committee, and summarizes evaluation of these concepts. Chapter 5 provides conclusions and recommendations concerning work to be pursued on the conceptual designs.

Appendices A to C contain detailed information concerning the small aircraft in operation in Canada, and the associated carriers. Appendix D provides representative dimensions of common wheelchair types. Appendices E and F describe currently available boarding and in-flight chairs and level change devices, respectively. Appendix G lists the contacts made by the project team among air carriers, airport managers and lift manufacturers. Appendix H contains the results of the design evaluation according to the criteria developed in Chapter 3. Appendix I lists the members of project review committee who generously contributed valuable knowledge and advice to the project.

CHAPTER 2: THE CURRENT SITUATION

This chapter provides background information regarding the current situation for disabled travellers in small aircraft. The characteristics of mobility impaired passengers are discussed, as are the potential numbers of travellers in Canada. Current types of aircraft, wheelchairs and accessibility devices applicable to this study are reviewed. Specific aircraft characteristics are chosen for comparative purposes. Feedback from air carriers and airports regarding current practice is also presented.

2.1 USER CHARACTERISTICS

The Nature of Difficulties Encountered

The difficulties encountered by mobility impaired travellers are grouped in two main areas; (i) boarding and deplaning and, (ii) airline service. In-cabin mobility is not addressed here as it is not as critical for short trips, nor is it in the scope of this work.

Boarding and deplaning: The process of boarding an aircraft starts once the passenger leaves the waiting area and ends when the passenger is seated in the aircraft. For a physically disabled person, this process involves reaching the aircraft, either by way of loading bridge or traversing the tarmac, and a level change to the aircraft door. The passenger must then be transferred from the boarding chair into the aircraft seat.

In virtually all cases, a wheelchair user must be transferred from his/her personal wheelchair into one provided by the airline for boarding. These transfers are carried out manually.

Mobility impaired travellers are enplaned using a variety of methods, which can differ depending upon the airline, the type of aircraft and the airport. Larger airlines using larger aircraft serving larger airports can usually provide the disabled traveller with some type of electrically-powered boarding device and a specially designed boarding chair. Some larger aircraft are equipped with specially designed in-flight wheelchairs. Smaller, commuter airlines, which serve smaller airports in remote locations, often rely on manual lifting procedures.

Some specific difficulties experienced by mobility impaired air travellers are noted below. Note that these items do not necessarily represent the majority of cases.

- o Lack of proper boarding equipment;
- o Manual lifting, with or without a proper boarding chair, on and off the aircraft;
- o Varying levels of experience and training of airline personnel;
- o Psychological factors, including fear and embarrassment of being bodily carried to the aircraft seat;
- o Seat design, including fixed aisle-side arm rests and insufficient leg room;
- o Being "forgotten" during boarding and deplaning procedures. Not being pre-boarded;
- o The waiting time accompanying boarding and deplaning;
- o Lack of availability of personal wheelchairs during stops. Use of an airport chair instead (which can be poorly designed) and;
- o Shortage of airport wheelchairs.

Airline service: The mobility impaired traveller's major concern regarding the airlines is the lack of consistency in procedures. One traveller commented;

> "There is very little consistency as to accommodations that can be expected, and attitudes toward offering accommodations, even within one airline from one plane to another, or from one airport to another. It is not like accessibility in the rest of the environment. There is some sort of minimum standard of acceptability. With airlines you can't make these assumptions at all. It is an added frustration." [1]

Air carriers' policies vary greatly. Some of the stated inconsistencies that occur from one carrier to another include:

- o Whether electric wheelchairs or wet-celled batteries are allowed to be carried;
- o Whether a personal attendant is required and whether the attendant is required to pay full or half fare; and
- o Level of care in handling wheelchairs during transport.

Difficulties that disabled travellers have encountered with a number of carriers include:

- o Carrier personnel confusion as to which aisle arm rests are moveable;
- o Carrier personnel confusion as to who is responsible for assisting the passenger in boarding and deplaning;

- In the case of transfers, not being assured of a seat which is easily accessible, or stowage of a wheelchair;
- Uncertainty as to what to expect at other stops during the trip;
- Lack of information provided by check-in staff;
- Having to give pre-notification to the carriers of required wheelchair stowage or other special assistance.

Quite often, the problem is not the policies and procedures themselves, but the confusion of airline personnel regarding these policies and procedures. Often staff are neither trained nor experienced in their application. Many of the difficulties listed above stem from this factor.

There is currently a lack of an industry-wide standard of service, which leaves the mobility impaired passenger guessing as to the type of barriers he/she may have to deal with during each trip. There is also a lack of accurate information available concerning air travel for disabled persons. Even consistently using the same airline does not necessarily eliminate the uncertainty, because many airlines do not have formal company-wide guidelines which personnel are expected to follow.

Quantification: The 1983/84 Canadian Health and Disability Survey (CHDS) is arguably one of the most comprehensive databases with regard to intercity transportation by disabled persons. The data below reflect published and derived results (generated in special runs and cross-references regarding intercity transportation):

The type of trouble mobility impaired air travellers encounter (shown as a percentage of all of those who have trouble):

Boarding/disembarking	41%
Moving around in the terminal	37%
Seating on board	22%
Washroom facilities	15%
Hearing announcements	12%
Seeing signs or notices	11%
Transporting wheelchair or other special aids	--
Carrier rules and regulations	--
Other	42%

The Canadian Transport Commission / Labour Force Survey (1983) quantifies the major forms of assistance used by mobility impaired air travellers:

Special assistance	48%
Personal attendant	46%
Walking aids	45%
Wheelchair provided	32%
Wheelchair owned	16%

Note that some of the assistance mentioned above may be due to the barriers created at the airport (such as long walking distances, extra level changes, etc.), as much as an individual's disability.

Population Totals

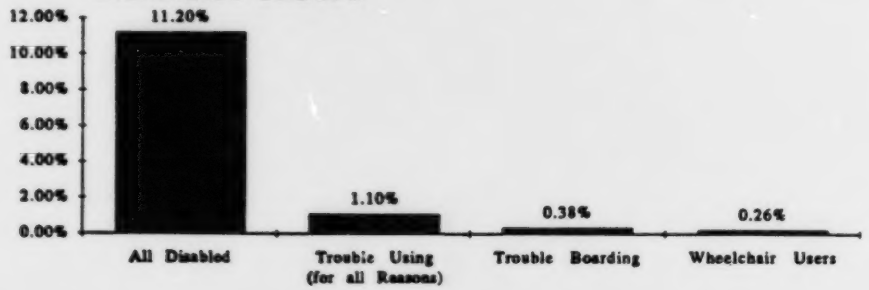
Table 2.1 and Figure 2.1 reflect the estimated number of disabled persons in Canada. The data comes from published and derived results from the CHDS (generated by in special runs and cross-references regarding intercity transportation).

TABLE 2.1: POPULATION OF DISABLED PERSONS - AIR TRANSPORTATION

Group	Number in Canada	Percentage of Total Canadian Population
Total Canadian population (survey base):	19,136,000	100.0 %
Total disabled population, non-homebound:	2,139,000	11.2 %
Mobility impaired persons:	1,598,000	8.4 %
Wheelchair & walker users:	101,000	0.53%
Trouble using airplanes (for all reasons)[5]:	204,000	1.1 %
Trouble boarding:	72,000	0.38%
Wheelchair users:	50,000	0.26%

Source: Special runs of the CHDS

FIGURE 2.1: AIR TRANSPORTATION IN CANADA: RELATIVE SIZES OF THE DISABILITY GROUPS



Note: Percentages are expressed as a percentage of the 1984 adult population in Canada (19.1M persons). Those who are homebound are not included

Source: James F. Hickling Management Consultants Ltd., Special Runs of the CHDS.

5 Those who are also: adult, disabled, and not homebound.

Trip-Making Estimates

Current: Estimates of the total ridership of the general population on airlines in Canada are shown below in Table 2.2:

TABLE 2.2: ESTIMATED ANNUAL RIDERSHIP ON AIRLINES IN CANADA

Airline	Annual Ridership (passengers/year)
Air Canada	11,300,000
Canadian Airlines Intl.	2,600,000
Foreign carriers (est.)	6,000,000
Time Air	600,000
InterCanadian	300,000
Norcan Air	100,000
Others (est.)	1,500,000
TOTAL (Annual)	22,400,000
SMALL AIRLINES (Annual)	**2,500,000**

Source: Verbal quotations from carriers, and Statistics Canada data.

The 22 million passengers per year agrees reasonably well with other estimates from Statistics Canada. Assuming that the number of passengers on small aircraft is approximately equal to the number of passengers on small carriers, we see that approximately 2.5 million passengers use small aircraft per year. This corresponds to 11% of the total passenger traffic in the country.

Table 2.3 shows the ridership by various disability groups in Canada in 1983/84, on all aircraft (from the CHDS), and on small aircraft (11% of the total for all aircraft).

TABLE 2.3: ESTIMATES OF CURRENT RIDERSHIP (1984)

Disability Group	Ridership (passengers/year)	
	All Aircraft	Small Aircraft
Mobility impaired persons who have trouble using air transportation	119,000	13,400
Disabled persons who have trouble boarding/disembarking	48,000	5,400
Wheelchair users who have trouble using air transportation	6,000	680

Source: Special runs of the CHDS and Table 2.2.

Thus, the current ridership by mobility impaired persons on small aircraft in Canada is in the order of 13,000 passengers per year (or 260 passengers per week). Wheelchair users take approximately 680 trips per year, or 13 trips per week.

Verbal estimates from carriers vary tremendously, but are nonetheless within the same order of magnitude. Some quotations are given below.

- "Two wheelchair users are carried per week, and 30-40 per week have trouble boarding."
- "We see one wheelchair user per week, and 25 per week who have trouble boarding."
- "1-2 wheelchair users are turned away per week."
- "15 passengers per day use a boarding chair, and 40-50 per day have mobility problems."

Future: To estimate a reasonable upper limit for the number of disabled air travellers in future, a **barrier-free society**, i.e., disabled users travel at the same rate as the general population, was assumed.

The total ridership on small airlines in Canada is 2.5M passengers per year. In a barrier free society, the same proportion of disabled people would travel as the general population. Applying the 8.4% and 0.53% values of Section 2.1, gives the following estimates of **maximum** ridership on small airlines across Canada;

Mobility impaired persons:	208,000 passengers/year	(4,000/week)
Wheelchair users:	13,000 passengers/year	(260/week)

2.2 AIRCRAFT TYPES

Although the necessity of carrying a mobility impaired passenger is a relatively rare occurrence on small aircraft (roughly 0.5% of all small aircraft passengers), the potential disruption in service to passengers as a whole can be significant. The manual lifting of passengers onto aircraft is probably the fastest method, but is discouraged by regulatory agencies, user groups and the carriers themselves. Alternative mechanical lifting methods such as forklift/pallet arrangements can be more time consuming and interfere with the regular passenger flow.

Several additional problems exist in relation to small aircraft that are not present when accessing larger aircraft. These include the following.

- A wider variety of small aircraft are in service than large aircraft in Canada, (shown in Table 2.4) with more significant dimensional differences. The differences in accessibility problems between a 19 seat aircraft and a 52 seat aircraft are much greater than those between a Boeing 727 and 747. In some cases, small carriers use older, retrofitted aircraft because of the cost benefits. These aircraft add to the variability of the already diverse small aircraft fleets.

- There is a potentially higher "cost per trip" for accessibility to small aircraft. Fewer staff are available at the smaller airports and there is a lower demand for special services. The cost of carrying a wheelchair can be as high as $150,000 per year for a large carrier. Development costs for a new flip-up arm rest are estimated by British Airways to be $130,000 [2]. Small carriers have significantly smaller budgets than Air Canada or Canadian Airlines for such expenditures.

- Many smaller aircraft are equipped with airstair doors, where stairs are built into the cabin door and are ready for use when the door is flipped down. The carrying capacity of many of these airstairs is questionable when they have to support two attendants carrying a passenger in a boarding chair. The airstair of the Twin Otter, for example, is estimated to have a load capacity of 250 lb (115 kg).

- Some small aircraft, such as the Jetstream 31 and the Twin Otter, have aft loading cabin doors. This arrangement makes it difficult to board passengers in boarding chairs in the same orientation as the aircraft seats. Maintaining the same orientation is desirable because of limited turning room in the aircraft vestibule. In these cases, passengers must face forward when being lifted up the stairs, and as a result may be tilted backward at more than a 90 degree angle.

- Small aircraft have limited cargo carrying capacity. Carrying a large item such as an electric wheelchair while accommodating other passenger baggage is very difficult. Related to this are centre of gravity characteristics that can be significantly affected by a heavy item like an electric wheelchair on a smaller aircraft.

TABLE 2.4: PRINCIPAL AIRCRAFT TYPES BY WEIGHT GROUP, USED BY LEVEL 1-V AIRCARRIERS, 1970, 1985[1]

Weight Group	Description	Designator	Number of Aircraft 1970	1985
Small Aircraft (less than 60 passengers)				
A	Cessna Commuter	C150	287	340
	Cessna Skyhawk	C172	162	372
	Cessna Skywagon	C185	108	228
	Cessna 180	C180	255	82
	Cessna 402	C402	-	38
	Piper Cherokee	PA28	153	119
B				
	De Havilland Beaver	DHC2	159	219
	Piper Aztec/Apache	PAZP/PA23	125	135
	Piper Navajo	PA31	13	151
C				
	De Havilland Otter	DHC3	63	99
	De Havilland Twin Otter	DH6	20	79
D				
	McDonnell Douglas Dakota	DC3	62	57
	McDonnell Douglas Invader	A26	2	25
E	Convair 580	CV58	0	20
	Hawker Siddeley 748	A748	0	26
	De Havilland Dash 7	DHC7	-	13
	De Havilland Dash 8	DHC8	-	23
	Jetstream 31	BA14	-	- [2]
	Metroliner III	FA3	-	- [2]
Larger Aircraft (more than 60 passengers)				
E	McDonnell Douglas Skymaster	DC4	13	16
F	Boeing 737	B737	19	73
	McDonnell Douglas DC9 Series 30	DC93	36	35
G	Boeing 727	B727	4	37
	Boeing 767	B767	0	14
	McDonnell Douglas Super DC8	DC86	22	16
H	Boeing 747	B747	0	12
	Lockheed Tristar/Tristar 500	L101/L105	0	18
	McDonnell Douglas DC10	DC10	0	11

[1] Figures are as of January 15, 1971 and 1986.
Source: Statistics Canada/Canadian Transport Commission - Fleet Report

[2] Forecasts of carrier fleets indicate that the use of these craft will increase in the next five years.

Rationale for Selection of Aircraft

For the purposes of the project, the various small aircraft that are currently operated by Canadian carriers were examined. The project review committee also made mention of small aircraft that were expected to become prevalent in the near future. Six aircraft were selected to represent the majority of small planes currently being used on Canadian commercial flights. These aircraft were chosen to aid in the design process, representing a range within each of the following criteria:

- Door & aisle dimensions and characteristics (e.g. entrance stairways, aisle width, etc.);
- Number in service;
- Cargo hold capacity;
- Size & seating capacity (special emphasis was placed on aircraft with less than 20 seats since the larger craft are more able to handle disabled passengers);
- Destinations served and;
- Associated carriers.

Table 2.5 summarizes the relevant dimensional and configuration data for each of the selected aircraft.

A discussion of the principal characteristics that lead to selection of each of the aircraft follows.

Cessna 402: The Cessna 402 - business version was chosen primarily because of its very narrow aisle width of 8.3 inches (21 cm). It has a small capacity, holding only 9 passengers, and 26 are in commercial service. The 402 has an unusually large seat pitch for its size, at 35 inches (90 cm).

Dash 8: The Dash-8 Series 100 represents larger commuter aircraft, has a large passenger door and cargo hold capacity, and carries between 36 and 40 people. There are 23 in commercial service in Canada and they are used by several carriers.

Twin Otter: The DeHavilland Twin Otter was chosen because it is a 20 seater and there are a relatively large number in service in Canada. The cabin door for passenger loading is located in aft of the cabin.

Convair 580: The Convair CV-580 and CV-640 are similar except in engine configuration. They both hold approximately 50 passengers and have large cargo holds. The passenger door is high off the tarmac at 92 inches (2.3 m) when the craft has a medium size load.

TABLE 2.5: AIRCRAFT SELECTED FOR DETAILED ANALYSIS

Aircraft	Number in Service in Canada	Dimensions							
		Seating Capacity	Tarmac/ Sill	Tarmac/ First Step	Cabin Door	Aisle Width	Seat Configuration	Cargo Door	Cargo Hold Capacity
Cessna 402	26	9	30"	air stair 8"	24"W x 50"H	8.3 for Business 11.3" for Utility	1 on each side of aisle Pitch: 35"	Nose: 33.8"W x 12.8"H	Nose: Dimensions: 31.3"W x 50.8"L x 12.8"H Volume: 26 cubic ft. Weight Limit: 300 lb
								Aft: 17.5"W x 47.7"H	Aft: Dimensions: 47" x 19" x 38.5" and 41.7" x 16" x 27.7" Volume: 31.7 cubic ft. Weight Limit: 400 lb and 100 lb
Dash-8 Series 100	40 (30)	36/40	43"	air stair 11.0"	30"W x 65"H	15"	Pitch: 31" Width: 17.3"	50"W x 61" H	Dimensions: 105"L Volume: 300 cubic ft. Weight Limit: 2000 lb
Twin Otter Series 300	60	18/19	47"	air stair	30"W x 45.5"H behind wing	10"	double and single rows Pitch: 30"	Nose: 29.7"W x 27.2"H	Nose: Dimensions: Volume: 38 cubic ft Weight Limit: 300 lb
								Rear: 26" W x 37.3"H	Rear: Dimensions: 74"L Volume: 88 cubic ft Weight Limit: 500 lb
CV-580 or CV-640 (same except for engines)	28	44 original 50 and 52 conversions	92", but ranges 89-102"	air stair normal step	36"W x 83"H	Original 18" and Converted 16.5".	2 & 2; Pitch: Factory 35" Converted, 31 or 32"	Upper Forward: 36"W x 48"H	Upper Forward: Dimensions: 26.5 sq. ft Volume: 152.7 cubic ft Weight Limit: 1800 lb
								Upper Aft: 28"W x 48"H	Upper Aft: Dimensions: 31.6 sq. ft. Volume: 192.8 cubic ft. Weight Limit: 1800 lb
								Belly: 38"W x 36"H	Belly: Dimensions:47.4 sq. ft. Volume: 77.8 cubic ft. Weight Limit: 1000 lb

TABLE 2.5: AIRCRAFT SELECTED FOR DETAILED ANALYSIS (continued)

Aircraft	Number in Service in Canada	Dimensions							
		Seating Capacity	Tarmac/ Sill	Tarmac/ First Step	Cabin Door	Aisle Width	Seat Configuration	Cargo Door	Cargo Hold Capacity
Jet Stream 31		18/19	48"	air stair	34" W x 56"H behind wing	15"	Double on right, single on left. 3 at the back. Pitch: 29" on left, 30" on right, 39" emerg. exit. Seat Width: 16.5"	Aft: 26.8"W x 35.5"H	Aft: Dimensions: 90.6"L x 47-58"W Volume: 74 cubic ft. Weight Limit: 628 lb
								Pod:	Pod (optional): Dimensions: 10'9"L x 3'11"W x 1'4"H Volume: 49 cubic ft.
Metro III		19	50"	air stair 18-24"	25"W x 53"H Short: In back of wing. Long: In front of wing.	14"	Single seating, 3 at the back.	Aft: 51.25"W x 53"H	Aft: Dimensions: 53"W x 92.75"L Volume: 136 cubic ft. Weight Limit: 850 lb.
								Forward: ~19"W	Forward: Dimensions: Volume: 30 cubic ft. Weight Limit: 600 lb.

Jetstream 31: The Jetstream is a 19 seater aircraft. The U.S. has a significant number in service and the number of these planes in Canada is expected to increase in the future. The Jetstream has an aft loading cabin door. Although this door is wide, a right turn must be made from the entrance landing through a very narrow cabin entry door. It would be very difficult to effectively assist or carry a disabled passenger through this door [3]. Although the cargo capacity is probably sufficient to accommodate most wheelchairs, the cargo door is small and is located inside and at an angle to the passenger door. Cargo must then be carried up the stairs and partly into the cabin before being turned into the cargo hold [4]. Large items such as electric wheelchairs would make this procedure awkward and dangerous.

Metro III: The step from the tarmac to the first stair of the Metroliner III is high at 18 to 24 inches (46 to 61 cm). This would be an obstacle for stair mounting level change devices and would be unstable for someone being manually lifted. The fuselage tube is smaller than that for most planes of this type. Though there are no Metroliner III's currently in commercial use in Canada, there are over 200 in American carriers' fleets, and it is expected that several of the Metro II's currently operated by Canadian carriers will be replaced by Metro III's. The Metro II has similar door and seat configurations to the Metro III.

The features of the selected aircraft described above were used in the development of design constraints and criteria. Illustrations and dimensional data concerning the selected aircraft are contained in Appendix C.

2.3 PERSONAL MOBILITY AIDS

Mobility impaired passengers arrive at the airport with their own personal mobility aids, including wheelchairs, canes or guide dogs. Depending upon the airline practices and the characteristics of the scheduled aircraft, these aids will be stowed in cargo areas or in the aircraft cabin. Because of restricted physical dimensions, it may be impossible to accommodate large devices such as electric wheelchairs in the cabin or even the cargo areas.

Air carriers often provide specialized boarding chairs to aid mobility impaired passengers once their personal devices have been packed and stowed. Commonly available boarding chairs, however, are not designed to traverse the narrow aisles of small aircraft.

Wheelchair Stowage Considerations

Several operational aspects of wheelchair stowage in small aircraft are discussed below.

- The additional space required for the baggage of other passengers can cause difficulty when stowing wheelchairs. For example, the Dash-8 carries up to 40

passengers. If each passenger had baggage equivalent to the size and weight of an electric wheelchair, the total required volume and weight capacity would be more than double that available in the Dash-8. Though allocating these volumes and weights to average passengers' baggage is unrealistic, it is evident that if passengers carry even half those volumes and weights, baggage handlers will have serious logistical problems loading around a wheelchair. Also, it is usually preferred to avoid loading baggage or cargo on top of wheelchairs (to reduce the possibility of damage). Therefore, the wheelchair often occupies the space above it as well as the actual volume it displaces.

- Wheelchairs often have delicate components, such as joystick controls, that may easily be damaged during normal packing and handling. Some parts may come loose during handling and may be replaced incorrectly.

- Some carriers will not carry wet-cell batteries so as to avoid battery acid spillage. The wheelchair owner may then have to arrange to have a battery waiting at his/her destination.

- A mobility impaired passenger that initially boarded a large aircraft may change to a small aircraft to continue the next leg of the journey. Interlining without advance notice may cause problems for the personnel responsible for the second aircraft. A wheelchair stowed on the initial aircraft may be impossible to fit into the second. The project review committee suggests that a wheelchair/aircraft chart be developed to indicate which models of wheelchairs may be stowed on which models of aircraft. This chart could be included in a complete wheelchair stowage guide for carrier personnel. The ability to handle the wheelchair on each leg of the journey may then be assured at the time of reservation.

- Electric wheelchairs may have to be disassembled to fit into the cargo holds of certain aircraft. Again there is the possibility of damage to the chair, of losing parts, or of improper assembly at the passenger's destination. Proper assembly instructions are rarely available [6].

- If no advance notice is given to the air carrier, the wheelchair stowage process may delay the flight.

- Electric wheelchairs are a relatively heavy cargo item, and can disturb the weight balance of light aircraft. This problem is amplified when the aircraft is carrying a small passenger load. (More room for baggage, less tolerance of heavy item).

- Small aircraft are often loaded manually from the tarmac. The weight of an electric wheelchair may strain cargo handlers when they are lifting the chair, often above shoulder level, into the cargo hold.

A database of well known manufacturers' standard wheelchairs was scanned to estimate maximum and minimum dimensions [5]. Product literature on electric wheelchairs, scooters and sports wheelchairs was also examined to estimate typical dimensions. The resulting representative measurements are provided in Appendix D. These dimensions were used to determine whether each of the selected aircraft would be able to accommodate each of the different categories of wheelchairs.

(Table 2.5 presents the dimensions of the cargo holds of each of the selected aircraft.) Most electric wheelchairs are approximately the size of a large standard wheelchair, though they are heavier. The weight of electric wheelchairs therefore requires special consideration when evaluating stowage on smaller aircraft.

Discussion of the stowage capabilities of each of the selected aircraft is given below. The stowage characteristics are determined by dimensional and weight limit considerations only; the operational difficulties described above and aircraft centre of gravity considerations cannot be estimated without more detailed analysis.

Cessna 402: The Cessna 402 has nose and aft compartments for carrying cargo. It is not possible to fit any of the representative wheelchairs into these holds, except for the minimum standard folded wheelchair which squeezes into both. Little room is left, however, for additional cargo. The centre of gravity factors should not be an issue because of the low weight of a small standard wheelchair (approximately 40 lbs.)

Dash-8: The Dash-8 has sufficient cargo door and cargo hold dimensions to admit and store all of the representative wheelchairs. The weight limit of 2000 lbs imposes no restriction, even for the heavier electric wheelchairs.

Twin Otter: The Twin Otter has limited cargo space. The nose compartment will not admit any of the representative wheelchairs. The rear compartment will admit all but the electric wheelchair if the single door configuration is used.

Convair 580: The Convair 580 is the largest of the selected aircraft. Not surprisingly, each of the representative wheelchairs will fit into the three available cargo holds. The weight capacities are also sufficient to carry an electric wheelchair.

Jetstream: The aft cargo hold in the Jetstream should accommodate each of the representative wheelchairs according to door and hold dimensions. The Jetstream has an aft loading passenger door which must also be used for loading cargo. The interior vestibule configuration makes manoeuvering a large item, such as an electric wheelchair, very difficult. In an experiment performed by some U.S. carrier personnel an electric wheelchair had to be disassembled to fit into the cargo area [7]. Even then it appeared to take up a significant amount of room, with the potential necessity of having to load other baggage on top, an action that might result in damage to the wheelchair.

Metro III: The Metro III has sufficient dimensions to admit and allow stowage of each of the representative wheelchairs. The weight limit of 850 lbs does not preclude a heavy chair. Space and weight limitations however, will likely restrict additional passenger baggage.

To comprehensively examine wheelchair stowage on small aircraft, a detailed study needs to be performed, including actual trials of fitting wheelchairs into cargo holds, and the impact of stowing wheelchairs on the accommodation of other passenger baggage.

Boarding Chairs

Currently available boarding chairs have been designed primarily for large aircraft with aisle-widths of greater than 15 inches (38 cm). Most are foldable, have an approximate seat height of 20 inches (51 cm), to be level with aircraft seats, and have a maximum load capacity of 300 lbs (136 kg) [8]. Small aircraft, on the other hand, may have aisle-widths as narrow as 9 inches (23 cm).

Table 2.6 indicates which of the listed boarding chairs will traverse the aisle of the selected aircraft, given one inch (2.5 cm) total clearance. The listed boarding chairs were chosen to represent the majority of those currently available. (See Appendix E) Figure 2.2 shows the dimensional data for an example boarding chair.

Table 2.6 demonstrates that very few boarding chairs have suitable dimensions for traversing the aisle of small aircraft. Although the Brockway Air Prototype fits in several of the selected aircraft, this experimental model is considered too small and unstable to safely transport disabled passengers. The other boarding chairs fit only the CV-580, the largest of the selected aircraft.

Additional problems associated with use of available boarding chairs on small aircraft include the following:

- Some small aircraft, such as the Jetstream 31 and the Twin Otter, have aft loading cabin doors. This arrangement makes it difficult to board passengers in boarding chairs in the same orientation as the aircraft seats. In these aircraft, if passengers face forward when being lifted up the stairs, they may be tilted backward at more than a 90 degree angle.

- Many passengers using boarding chairs feel insecure when being lifted, especially since the chairs, out of necessity, have narrow seats. Few of the existing boarding chairs are equipped with suitable straps and securement devices.

- Some of the small aircraft, such as the Jetstream and the Metro III have sunken aisles. This can make aisle traversal and passenger transfer from the boarding chair to the aircraft seat more difficult.

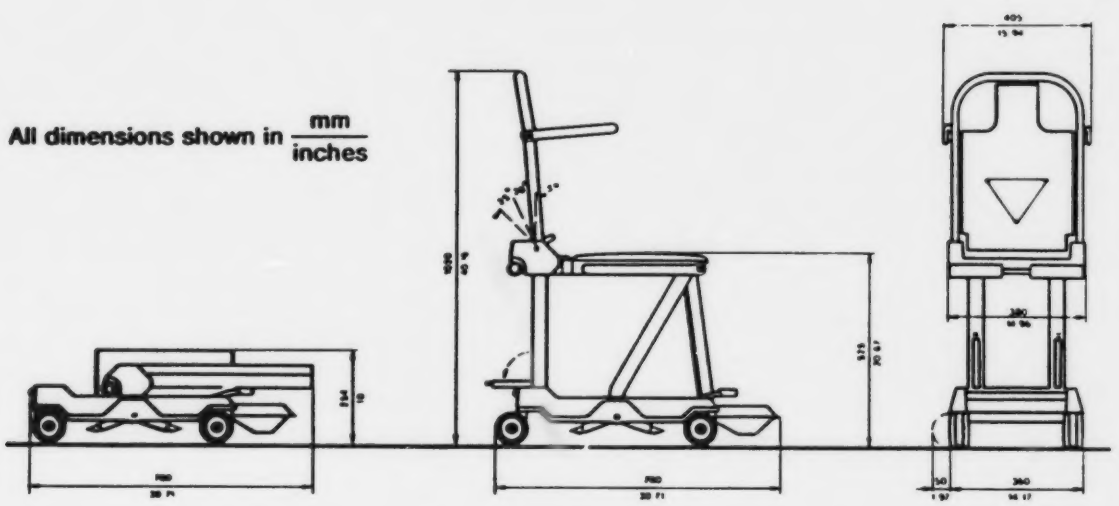
- In small aircraft, the vestibule area immediately within the cabin door often has very limited space for manoeuvering a boarding chair.

TABLE 2.6: FIT OF BOARDING CHAIRS IN SMALL AIRCRAFT AISLES

(aisle width) [optional width]	Cessna 402 (11.3") [8.3"]	Dash-8 (15")	Twin Otter (11")	CV-580 (18") [16.5"]	Jet Stream (15")	Metro III (14")
Amigo	-	-	-	-	-	-
Escort (18" w/o arms)	-			-		
Travel Mate (17.3")	-	-	-	-	-	-
	-			-		
Brockway Air	-	+	-	+	+	+
Prototype (11")	-			+		
Airline Transfer Chair (21.5")	-	-	-	-	-	-
	-			-		
I. Dee M. Chair (16")	-	-	-	+	-	-
	-			-		
Vogel Seat (16")	-	-	-	+	-	-
	-			-		
Washington Chair (15")	-	-	-	+	-	-
	-			+		

- will not traverse
+ will traverse

FIGURE 2.2: DIMENSIONAL DATA OF EXAMPLE BOARDING CHAIR



SPECIFICATIONS OF AIRBUS INDUSTRIE ON-BOARD WHEELCHAIR (VOGEL SEAT)

2.4 CARRIER AND AIRPORT PROCEDURES

Air Carrier Procedures

A number of air carriers which collectively operate all of the various candidate aircraft were contacted (see Appendix G). Some of the issues discussed and information obtained as it relates to air carrier procedures follow.

Advanced Notice: A number of carriers express the need to be made aware of requests for special assistance at the time of the initial reservation. Disclosure of the passenger's needs at this time allows the airline representative to arrange for special boarding equipment and/or seating locations. In addition, if the particular flight being requested uses an aircraft which requires considerable physical effort and risk in boarding for both the passenger and the airline personnel, alternative flights on more accessible aircraft may be suggested. For example, one airline carrier which is operating the Jetstream 31 is unable to serve disabled passengers primarily because the boarding chair they use is not compatible with the cabin layout. Advance notice allows the airline to find alternative service for the passenger who cannot be served on the Jetstream.

On occasion, when a disabled passenger arrives without notice, air carrier personnel have manually carried the disabled passenger without the use of the boarding chair. The carrier feels that this is an undesirable situation, but wishes to serve the passenger.

The Department of Transportation (DOT) proposed regulations in the Air Carrier Access Act include the following for Advance Notice Requirements:

> "Carriers could not require advance notice from handicapped persons except for the following services: use of medical oxygen, use of an incubator, respirator hook-up, accommodation of a stretcher, provision of an on-board wheelchair, or provision of hazardous materials packaging for a battery. Carriers could require 48 hours notice for these services." [12]

The "on-board" chair referred to is for in-flight use only; the proposed regulations do not include provision.

Pre-Boarding: Pre-boarding and post-boarding procedures are used by virtually all air carriers. Upon check-in (typically 1 hour before departure) the airline agents confirm the requirements for special boarding needs and passengers are made aware of the pre-boarding arrangements. In addition, when electric wheelchairs are accompanying the passenger, the passenger is transferred to a standard foldable wheelchair upon check-in, to allow for preparation of the electric wheelchair for travel (i.e. battery removal and packaging). Dry cell or gel type batteries are generally permitted and wet cells are usually only carried if battery transfer packs are available.

Typically, disabled passengers are escorted to the aircraft on the apron of the runway in a standard foldable wheelchair (where available). The passengers then board the aircraft in one of three ways, depending on the aircraft type:

- They are most often transferred to a high-back boarding chair and then carried up the airstairs into the aircraft;

- The boarding chair is placed on a platform which is vertically lifted (usually by a conventional forklift) to the same elevation as the aircraft cabin floor and then wheeled on board;

- The disabled passenger is manually carried up the airstairs by carrier personnel into the aircraft without the aid of boarding equipment.

Communications: A number of airline operators indicate that communication networks currently exist between origins and destinations to ensure that information regarding passenger needs are relayed. While the systems vary from airline to airline, typically a teletype message is dispatched to the destination indicating any special passenger requirements on the flight. This procedure is followed even when there are no special requirements. In addition, the incoming pilots will confirm with the airline operators that special equipment is standing by prior to their arrival at their destination.

Attendants: The issue of when disabled persons are required to travel with attendants and what fare these attendants should pay is contentious in both Canada and the U.S. The National Transportation Agency (NTA) in Canada has drafted provisions for such attendants or assistants. These provisions recognize an individual's self-assessment of disability except where the carrier feels that the person's condition may pose a safety risk to himself or to other passengers. Only persons with medical certificates confirming the need for an assistant are required to by accompanied by an assistant, who travels at no additional cost. [13]

The proposed DOT regulations in the U.S. state that carriers cannot require someone to have an attendant except in the four following cases:

- Someone travelling on a stretcher;
- Someone with a mental disability who could not understand safety instructions;
- Some deaf-blind persons (based on self-assessment); and
- Some quadriplegics (based on self-assessment).

Seating: A significant constraint in boarding passengers is the seating location within the aircraft cabin for disabled passengers. Transport Canada officials have drafted preliminary regulations which would prohibit the seating of disabled passengers adjacent to either floor level exits and/or window emergency exits. The implication of these regulations is that the disabled passenger must be transported up or down the aisle (depending on whether the aircraft boarding door is located in the front or rear of the cabin). However, the majority of the candidate aircraft do not have sufficiently wide aisles to accommodate boarding chairs. Currently, a majority of the carriers (primarily the larger ones) do not seat disabled passengers adjacent to exits, while some of the smaller carriers make use of the seat closest to the cabin door.

The DOT in the U.S. calls the issue of disabled passengers sitting in exit row seating a safety issue which is the responsibility of the FAA (Federal Aviation

Association). Currently, the DOT proposed regulation says that carriers cannot exclude persons from any seating on the basis of disability, except in order to comply with FAA safety regulations. FAA regulations in this matter have not yet been released, however, so that no effective restrictions on seating exist.

Airport Procedures

Operating and environmental conditions at individual airports within Canada were identified through discussions with the Airport Managers listed in Appendix G. A brief description of some of the major findings follows.

Terminal Accessibility: The primary role of the airport is to provide an interface between ground transportation and air transportation. In carrying out this function, the airports have attempted, where possible, to remove many of the physical impediments which restrict the movement of passengers through the terminai. The air carriers are responsible for providing necessary assistance to passengers from the time of check-in to the time of baggage pick-up at the destination.

While airport facilities were not originally designed to accommodate wheelchairs, they are being modified to increase accessibility. However, a great many of the airports, by nature of their design, prohibit to varying degrees the free movement of unaided wheelchair users.

Typically, the distance an individual must travel on the apron in order to board an aircraft increases greatly as a function of the airport size. For example, a number of gates at Pearson International Airport require that great distances be travelled from the waiting room to the tarmac before the passenger may be boarded. While a number of the barriers (typically stairs) are being modified (with stair climbers) and some of the small aircraft carriers are being consolidated into the small commuter terminal, great distances still exist between the waiting rooms and the aircraft.

Ground-Side Equipment: At the majority of the airports, the carriers are responsible for ground side equipment and maintenance. This includes any requirements for boarding chairs, etc. However, at some of the smaller airports, equipment such as stairways for larger aircraft are leased to the carriers. Baggage areas are generally leased to the air carriers operating at the individual airports.

Boarding: The boarding and deplaning of small aircraft occurs from the tarmac and, consequently, all passengers are exposed to the elements. In addition to the cold climatic conditions, the accumulation of snow and ice on the apron introduces an element of passenger safety and creates an operational constraint with respect to the deployment of ground side equipment.

2.5 LEVEL CHANGE DEVICES

The mechanical lifts currently used for aircraft can be grouped into the following categories [9]:

- Powered stairway climber;
- Combined stairway and powered lift platform;
- Forklift with pallet device; and,
- Vehicle with vertical lift compartment.

A summary of currently available level change devices is shown in Table 2.7. Further details are contained in Appendix F.

Although the majority of small aircraft incorporate airstairs as an integral component of the cabin door, stair climbers are not always appropriate as level change devices. The design of the airstairs varies greatly by size and type of aircraft. The height of the first step from the tarmac can be greater than a standard step height (as shown in Table 2.5)

A number of vertical lifts are currently being used for boarding passengers on both large and small aircraft. The majority of the equipment has been designed for aircraft in which the cabin door is high off the ground. These lifts have not been designed for aircraft which incorporate airstairs as an integral component of the cabin door. Consequently, current vertical lifts are not capable of being manoeuvred sufficiently close to the aircraft to be useful given the wide range and complexity of the cabin doorways and airstairs.

The Whitehorse Airport uses a loading bridge designed by the Jetway Corporation that can interface with aircraft with door sill heights as low as 70 inches (178 cm) [10]. This bridge tilts and telescopes, has a range of 170 degrees and can fold against the terminal building when not in use. The loading bridge is highly manoeuverable and can serve three parked aircraft. It benefits both disabled and able passengers, but still cannot board at the low door sill level of the smaller aircraft.

Designs Under Development

Mid-Canada Equipment Ltd. of Winnipeg has developed a design concept for a boarding device to facilitate access to commuter aircraft for non-mobile passengers. While it was initially well received by representatives of commuter aircraft manufacturers, the Regional Airline Association (RAA) and the Paralyzed Veterans of America (PVA), its development was recently discontinued. The primary reasons for this were the risk of impact with resulting damage to the aircraft, and the possibility of injury to persons aboard the platform. Mid-Canada feels that to develop a successful (and commercially viable) boarding device the following criteria must be met.

- o Compatibility with the physical configuration of popular commuter aircraft;
- o Self-supporting;
- o Safe with respect to passenger, attendant and aircraft;
- o Affordable;
- o Able to be positioned and operated by one person.

Mid-Canada plans to begin in-depth development of a new design concept. This concept has the potential of meeting all of the criteria identified above, as well as being compatible with the particular constraints imposed by the Metro III which led to the discontinuation of the earlier concepts.

Houle Hi-Reach Equipment Ltd. of Toronto have also indicated that they have developed a conceptual lift device which would provide the necessary lateral and forward motion to overcome the restrictions imposed by the airstairs on most small aircraft. Detailed information is not currently available.

TABLE 2.7: AVAILABLE LEVEL CHANGE DEVICES - COMPARISON CHART

Device Name	Manufacturer	Weight Load Capacity	Person Load Capacity	Power	Uses Built-In/ User's Chair	Term to Aircraft w/o transfer [1]	Protection from Elements	# Attendants Required	Security During Lift [2]	Height Range off Tarmac	Modification to Aircraft
POWERED STAIRWAY CLIMBERS											
Le Freeway	Aluweld/ France	120 kg	1	Battery	User's	Yes	No	1	Medium	Stairs	No
Escamatic	Baronmead Int'l Ltd.	250 kg	1	Battery	User's		No	1	Medium	Stairs	No
Edrey Power	Edrey Co.		1	Battery	User's	No	No	2	Low	Stairs	No
Stair Trac	Garaventa (Canada) Ltd.	130 kg	1	Battery	User's	Yes	No	1	Medium	Stairs	No
Stair Aid	Casco Zug AG		1	Battery	User's	Yes	No	1	High	Stairs	No
COMBINED STAIRWAY & POWERED LIFT PLATFORMS											
4-Function	Dahms & Co.		1	Battery	User's	Yes	No	1		Stairs	No
Combi-Stair	Invaco		1	Battery	User's	Yes	No	1		Stairs	No
PWA Lift	Pacific Western Airlines	200 kg	1	Battery	User's	Yes	No	1		Stairs	No
Monoclimber			1				No	2		Stairs	No

[1] take passenger fron terminal door to aircraft door without transfer

[2] for both passengers and wheelchair restraint

TABLE 2.7: AVAILABLE LEVEL CHANGE DEVICES - COMPARISON CHART

Device Name	Manufacturer	Weight Load Capacity	Person Load Capacity	Power	Uses Built-in/ User's Chair	Term to Aircraft w/o transfer [1]	Protection from Elements	# Attendants Required	Security During Lift [2]	Height Range off Tarmac	Modification to Aircraft
FORKLIFT WITH PALLET DEVICE											
Forklift/ Pallet	various		1	Battery	User's	No	No	1 to 2		0 to DC-9	No
VEHICLES WITH VERTICAL LIFT COMPONENT											
Plane Mate Mobile Loading Lounge			150 (3 wchairs)		User's	Yes	Yes		low	2 to 5.6 m	No
Handicapped Passenger Lift			5	hydraulic			Yes			727 to 747	No
Galley Service Truck			1 to 4	hydraulic	User's	Yes	Yes	1/passenger	low	2m to 747	No
Invalid Passenger Lift							Yes		low		
HELP			1 to 25				Yes				
Lift-O-Mobile		798 kg	1 to 4		User's	Yes	Partial	1 to 2	good	2.3 to 5.6 m	No

CHAPTER 3: INFLUENCING FACTORS AND DESIGN CRITERIA

To evaluate the design concepts developed in this report it is necessary to identify the influencing factors and design criteria associated with the manufacture of the proposed accessibility devices. This chapter discusses these factors and criteria as they apply to small aircraft accessibility.

3.1 INFLUENCING FACTORS

Knowledge of the influencing factors associated with a device for facilitating access to small aircraft early in the design process ensures conformity with existing constraints.

The influencing factors identified as part of this study include:

Logistics: Logistical considerations are critical if a potential device is to be used and accepted by both operators and users. Factors to be considered include the procedures for facilitating the enplaning or deplaning of passengers, i.e., pre-boarding and post-boarding, procedures for reservations, procedures for check-in and co-ordination between points of origin and destination and between interconnecting flights.

Aircraft Configuration: Aircraft considerations need to be reviewed carefully such that the maximum number of small commuter type aircraft will be accommodated by a candidate device. Factors include cabin door dimensions, height and location, the area available in the vestibule, aisle width, the availability of removable armrests and the availability of adequate storage facilities for mobility aids on-board the aircraft. It has been assumed for this study that physical modifications to the aircraft are precluded due to the significant cost and degree of complexity involved. Also, the Cessna 402 is removed as one of the representative aircraft since its physical dimensions are too restrictive for practical accessibility. Design effort is concentrated on 19 to 59 seat aircraft.

Regulations: Regulatory considerations include a wide variety of factors such as technical requirements for vehicles operating on the airport apron and applicable standards relating to elevating devices for the handicapped and to motor vehicles for transporting physically disabled persons. These considerations also include procedures for providing a safe interface between ground side equipment and the aircraft, legislation restricting the use of seats in proximity to exits,

and legislation ensuring equal access to travel by all members of the population and limitations associated with this legislation.

Operating Environment: Operating environment considerations include the need to be cognizant of the wide range of climatic conditions found in Canada as well as the influence that these may have on the surface condition of the apron area which is likely to be used by a potential boarding device.

User Requirements: User related considerations include the varying degrees of difficulty that will be encountered by different groups of mobility impaired passengers at various stages of travel from the airport terminal to the aircraft seat. In addition, the needs of an accompanying personal attendant must be accommodated.

Operator Requirements: Operator related considerations include such factors as the availability of personnel to assist mobility impaired passengers, operator acceptance of the potential device and an understanding of the extent of the operator's responsibility in regard to passengers.

Cost: Cost is obviously an important consideration in the development of any device. Ideally there would be no cost associated with providing this service to the mobility impaired. This is not however, a realistic scenario and some costs will continue to be incurred by the air carriers. Attempts should be made therefore to reduce total life cycle costs of the device, including both capital and operating costs. A life cycle cost less than or equal to the current expenditures for assisting the mobility impaired passenger (on a per passenger basis) should be targeted. Further research is required before an appropriate cost range can be developed. This range would likely have to accommodate the differing needs of carriers operating at large airports versus those of carriers operating at small airports.

Table 3.1 summarizes the various influencing factors and their associated constraints identified during the course of this study.

TABLE 3.1: INFLUENCING FACTORS AND CONSTRAINTS

Influencing Factor	Description	Constraint
Logistics	Prenotification	Full disclosure of special boarding needs at time of reservation. (Typically 24 hours is sufficient time in which to plan for the necessary arrangements.)
	Boarding	Preboarding commonly used for passengers requiring special boarding needs (1 hour advance check-in required)
	Deplaning	No constraint. (Although a communications network is in place to relay information to destination from origin at time of departure, procedures may need to be implemented to ensure consistent and continuous application.)
	Boarding/Deplaning	Boarding/Deplaning occurs on apron often requiring significant distances between departure lounge and aircraft in an unprotected environment generally exposed to the elements, (i.e. snow, ice and extreme weather conditions).
	Interconnecting Flights	Interconnecting flights often involve different airlines, when this is so, it is vital that any requirements for special boarding aids be passed along to each of the airlines to ensure no disruption to passenger service occurs.
	Mobility Aids	Electrically powered mobility aids must be checked-in with the carrier so that they may be prepared for carriage (i.e. battery storage, etc).
Aircraft	Cabin Door	o Door height range 116 to 215 cm (45.5" to 83") for selected aircraft. o Door width range 64 to 92 cm (25" to 36") for selected aircraft. o Tarmac to doorway sill range 100 cm to 127 cm (43" to 50") for selected aircraft. To accommodate all aircraft carrying 60 passengers or less, the range would increase to 76 cm (30 inches) to 260 cm (102 inches). o Access to cabin doorway is restricted due to: - doorway design (i.e. gull wing). - location of propellers
	Vestibule	Limited space within vestibule area. The Jetstream exhibits the most restricted situation with a sharp turn within the vestibule upon entering the aircraft.
	Aisle	Narrow aisles which impede access to seats. The Twin Otter (series 300) is the most restrictive with an aisle width of 25 cm (10 inches) while the Metroliner III is 35 cm (14 inches). Of the remaining aircraft only the Convair CV-580 can accommodate a typical boarding chair.
	Armrest	The carriers generally specify to the manufacturer the requirement for removable armrests. This feature increases the accessibility of the seats for all passengers.
	Wheelchair/Mobility Aid Storage	o Door height range 69 to 135 cm (27" to 53") for selected aircraft. o Door width range 66 to 132 cm (26" to 52") for selected aircraft. o Cargo hold volume range (74 ft^3 to 300 ft^3) for selected aircraft.
	Fore/Aft Passenger Entrance/Exits	For passengers to transfer to an adjacent seat they should be in the same direction (orientation) as the aircraft seats. For example, passengers should be placed adjacent to the aircraft seats facing forward in the same direction as the seats. Other factors include: front versus rear passenger cabin doors, available space in vestibule to rotate passenger within the vestibule and aircraft seat orientation.

TABLE 3.1: (continued)

Influencing Factor	Description	Constraint
Regulatory	Transport Canada Policy	For vehicles operating on the apron only (i.e. not on the taxiways), a rotating beacon is required only if the vehicle has a cab, if the vehicle does not have an enclosed cab 2 amber front and 2 red rear flashing lamps are sufficient. There is no requirement for firefighting equipment for equipment operating on the apron nor is there any requirement for two-way radio communication equipment, with the exception of Mirabel airport where apron movements are controlled by the tower and therefore all equipment must be equipped with two-way radios.
	Standards	Dependent upon the type of groundside equipment being considered, various CSA Standards may apply: o CAN3-B355-M86 Standard is entitled "Elevating Devices for the Handicapped". This standard specifies the minimum safety requirements related to design, construction, installation, operation, inspection and testing of elevating devices which are to be used by handicapped persons. o CAN3-D409-H84 Standard is entitled "Motor Vehicles for the Transportation of Physically Disabled Persons". This standard specifies the design and manufacture of the base motor vehicle used for transporting physically disabled persons, lifts, methods of securing wheelchairs and other aids, the methods of restraining passengers and ambulatory aids. o While neither standard (CAN3-A355-M86 and CAN3-D409-H84) is likely to be entirely applicable in the context of a boarding device for the mobility impaired, it would be desireable to incorporate as many of the guidelines as possible into the design, depending on the type of device being considered. In addition to these two CSA standards, federal CMVSS (Canadian Motor Vehicle Safety Standards) could apply according to the classification of vehicle being considered (i.e., passenger cars, buses, trucks and multi-purpose passenger vehicles, etc.) Should a device being considered fall into one of those groups of vehicles, they must comply with relevant standards pertaining to lighting, tires, brakes, fluids, controls, occupant protection, fuel systems and emissions.
	Interface between Groundside Equipment and Aircraft	The aircraft is vulnerable to damage from groundside equipment. Device designs must include consideration of general carrier practices and available standards.
	Seating	Pending legislation would require that Air Carriers establish procedures to ensure that seats located at emergency exits are restricted from use by any person whose presence in these seats may have an adverse affect on safety. However, until such legislation is adopted, it must be recognised that the seats adjacent to the entrance/exits are the most accessible to the mobility impaired and will, in all likelihood, be used by the carriers.
	Charter of Rights and Freedoms	The Ratushny Report suggests that the principle of "reasonable accommodation" is a pivotal concept in the handicap anti-discrimination law because it serves as a realistic middle ground between doing nothing and doing everything to assist handicapped people.[1] This simply means taking reasonable steps not to preclude persons with disabilities from participating as fully as possible in every aspect of our society. That goal has benefits not only for the disabled but for all of society. The extent of "reasonable accommodation" in transportation must be based on safety, in terms of technology and economics, as well as human rights considerations.

1 Ratushny, Ed, Special Advisor, Transport Canada. Air Accessibility Standards for Disabled and Elderly Persons, Ottawa, Transport Canada, 1984

TABLE 3.1: (continued)

Influencing Factor	Description	Constraint
Regulatory (continued)	Limitations to Access	An air carrier could refuse carriage to a person where reasonable grounds exist for believing that person's condition poses a risk to himself/herself or to other persons. This limitation to access is outlined by the National Transportation Agency of Canada (Notice dated 1988-5-12).
Operating Environment	Climatic	Exposure to severe cold, wind and precipitation.
	Surface conditions	Accumulation of snow and ice on the runway apron.
User Related	Mobility Impairment of Passengers	Mobility impaired passengers will have varying degrees of difficulty with four main travel stages from the terminal to their aircraft seat: 1. Airport terminal to aircraft on tarmac. 2. Tarmac to aircraft door. 3. Aircraft door to aisle position beside seat. 4. Aisle to seat. For example, an elderly passenger may have difficulty walking the distance from the airport terminal to the aircraft on the tarmac, but may be able to climb the airstairs and make their way to their seat. A wheelchair user may travel without difficulty from the terminal to the aircraft in their own chair, but may require assistance in the elevation change to the level of the aircraft door. These varied user needs must be accommodated to the maximum extent possible.
	Personal Passenger Attendants	Some disabled passengers will be travelling with personal attendants. Attendants should be allowed to remain with and assist the disabled passenger during boarding and deplaning procedures.
Operator Related	Personnel	Typically one or two persons are available to assist in boarding and deplaning. Small centres often will not have a designated person. A significant range of training and experience exists among the personnel available to assist mobility impaired passengers.
	Operator Acceptance	A device that would allow access for <u>all</u> passengers would likely increase acceptance by the air carriers.
	Responsibility for Providing Fully Accessible Air Transportation Services	Individual carriers are responsible for passengers from time of check-in including boarding and deplaning of all passengers.
Cost	Cost	Since air carriers are currently responsible for meeting the boarding needs of all passengers, a boarding device to aid in assisting mobility impaired passengers should attempt to minimize total life cycle costs. Total life cycle costs would include both capital and operating costs and should be less than or equal to current expenditures for assisting the mobility impaired passenger (on a per passenger basis).

3.2 DESIGN CRITERIA

Design criteria for the design and evaluation of potential accessibility aids for small aircraft are derived from the various influencing factors identified in the previous section. These criteria provide a basis for choosing a preferred solution among the various alternatives and provide guidelines for optimising these alternatives. Note that the framework is supplied as a checklist to ensure that all design criteria are considered, rather than as a purely analytical rating scheme.

The design criteria which have been developed for these accessibility aids have been formulated according to four major elemental categories: safety; functional adequacy; technical requirements; and, passenger requirements.

Each of the four categories is briefly described in the following paragraphs.

Safety: Issues such as the ability to meet relevant CSA standards, the interface between ground side equipment and the aircraft, the safety equipment requirements and passenger protection requirements are factors that are addressed as part of this design element.

Functional Adequacy: A critical element in the evaluation of any device is "How well does it meet the needs of the operator and/or user?". Consequently, design criteria developed within this group of design elements include such factors as personnel requirements, the time required to deploy the device, the need for pre-boarding of passengers, the portability of the device, the number of passenger transfers required, the climatic conditions under which it must operate and the time required for boarding.

Technical Requirements: Design criteria have been developed in relation to the relevant CSA standards, the degree of device flexibility to satisfy a wide range of operating constraints, the ability of the device to accommodate various small aircraft configurations, passenger positioning and transfer to seat requirements and various other factors including power, manual override, selection of components, design life, maintenance/servicing and control system features.

Passenger Requirements: Passenger requirements are a critical element in the design process. Issues concerning the device's exterior appearance, the degree of comfort offered the passenger, the level of effort required by the passenger for boarding, the speed of ascent/descent and the level of vibration, noise and exposure to inclement weather require consideration during the design process.

For each of the four broad categories above, specific design criteria have been developed. These criteria provide additional details on the particular design feature as it relates to each of the broad categories. Table 3.2 summarizes this information and indicates both the desirable (ideal) and minimum acceptable criteria for each of the factors.

In order to provide a structured means of comparison between the attributes of various designs, a weighing scheme for the design criteria has been developed. This weighting scheme is based on:

- The relative importance of each of the four categories of design elements with respect to each other and;

- The relative importance of each factor within the design element.

By multiplying each of these values, it is possible to develop weighting levels for each of the design factors. The suggested weighting levels associated with the development of a mobility aid for small aircraft are presented in Appendix H.

A rating or scoring scheme can then be applied to evaluate alternative designs. By assigning a value ranging from 0 to 10, it is possible to designate if the alternative fully meets the design factor ("10"), fails to meet it ("0") or falls somewhere between (a value ranging from "1" to "9").

Obviously some designs will be inferior to others when measured against the accepted design criteria and these will become apparent during the evaluation of the various alternatives. However, some deficiencies, which do not unduly constrain the concept, may be mitigated in order to improve the performance of the device while still maintaining its feasibility.

In addition to the application of the recommended design criteria, each of the alternative mobility aids for small aircraft must be further judged on:

- Whether the potential benefits of the various sub-systems are proportional to the costs of providing them and;

- Whether the cost of the device corresponds to market constraints.

The cost implications associated with a lift concept are important and will guide the ultimate design of a feasible lift device.

Although sufficient information is currently unavailable to identify an absolute maximum cost for a mobility aid for small aircraft, there will likely be a need to develop a device to suit the needs of both large and small carriers. Consequently, subject to confirmation through further research, reasonable production costs associated with small airports/carriers are likely to be in the range of $5,000 to $25,000 and with large airports/carriers, in the range of $100,000 to $200,000.

TABLE 3.2: SMALL AIRCRAFT ACCESSIBILITY DEVICE - DESIGN CRITERIA

Design Element	Suggested Design Criteria: Ideal	Suggested Design Criteria: Minimum Acceptable
Safety		
(a) Standards		Ability to meet relevant CSA Standards CAN3-B355-M86 and CAN3-D409-M84.
(b) Aircraft Interface		Provide complete protection to aircraft during use. Self-aligning. Positive immobilising position required for tarmac and aircraft floor interface.
(c) Groundside Interface; Vehicle Safety	All safety equipment can be carried on vehicle; No potential interference with other vehicles.	No danger to users or operators.
(d) Reliability of Equipment	Simple equipment: No possibility of stranding a user.	Complex equipment: Some possibility of stranding a user over the life of the equipment.
(e) Passenger Protection	Provide complete passenger body support.	Sufficiently stabilise and restrain passengers who require upper body and/or lower body support. No exposure to moving or rotating components. No risk to passenger safety as a result of operator error.
Functional Adequacy		
(a) Personnel	Minimal effort (1 person) required to transport, position and operate device. No personnel training required.	Moderate (2) persons 1 hour of personnel training to operate system.
(b) Time Required	Physical deployment time of 5 minutes.	Physical deployment time of 10 minutes.
(c) Preboarding	Not required.	Required.
(d) Physically Integrated System	Benefits both able and disabled passengers.	Does not impede the regular flow of passenger traffic.
(e) Portability	Easily moved into position by one operator.	Can be maneouvered by two operators.
(f) Number of Passenger Transfers	Minimise passenger transfer to two - one inside the terminal, the other adjacent to aircraft seat.	4 transfers maximum. (Including rolling into different lifts or vehicles).
(g) Climatic	Be capable of operating under severe weather conditions.	Be able to function under light snow, rain and extremely cold conditions. Be capable of operation on snow/ice surface.
(h) Passenger Boarding Time	Less than 3 minutes (tarmac to aircraft seat).	Less than 5 minutes (waiting room to aircraft vestibule).

Table 3.2 (con't)

Design Element	Suggested Design Criteria: Ideal	Suggested Design Criteria: Minimum Acceptable
Technical Requirements		
(a) Standards Applicable		Ability to meet applicable CSA Standards CAN3-B355-M86 and CAN3-D409-M84.
(b) Flexibility	Adaptable to airports of different sizes and operating characteristics.	Useful in only small or large airports; i.e. for either light or heavy loads (but not both).
(c) Aircraft Compatibility	Compatible with all aircraft used in scheduled service carrying 60 passengers or less.	Compatible with the 4 representative aircraft (Metroliner III, Jetstream 31, Dash 8, Twin Otter). o Minimum doorway height 116cm (45.5 in.) o Minimum doorway width 63 cm (25 in.) o Tarmac to aircraft floor 100 cm (40 inches) to 140 cm (55 in.).
(d) Aircraft Interface	No intrusion into the vestibule thereby maintaining maximum space available to aircraft personnel and/or persons assisting. No modifications to aircraft to accommodate the boarding device.	Minimal intrusion into the vestibule. Minor modifications to improve accessibility such as removable arm rests and airstair handrails.
(e) Passenger Positioning and Transfer to Seat	Provide means to transport passenger to appropriate seating location with 11" aisle width (i.e., Twin Otter). Upon entering vestibule allow passenger to either face the aircraft or away from the aircraft.	Provide means to transport passenger to appropriate seating location with 14 inch aisle width (i.e., Metro III).
(f) Power	Manually powered or powered by existing groundside equipment.	Self-contained source.
(g) Manual Override	Device should be equipped with an easily accessible manual override system requiring minimum effort by the operator. (1 minute execution time.)	Device should be equipped with an easily accessible manual override system requiring minimum effort by the operator. (3 minute execution time.)
(h) Existing Technology	Exclusive use of standard off-the-shelf components/hardware. Use of existing technology.	Maximum use of standard off-the-shelf components/hardware. Based on existing technology.
(i) Design Life	5000 cycles minimum	1000 cycles minimum.
(j) Maintenance/ Servicing	Not required throughout design life.	Comparable to other groundside equipment. Good access to all serviceable components.
(k) Control System Features	Simplify control system (self-evident controls, positive feedback, etc.). Failsafe device - in the event of power failure (average descent speed less than 7.8 metres/minute, where applicable). Standardized operating procedures under all weather conditions.	

Table 3.2 (con't)

Design Element	Suggested Design Criteria: Ideal	Suggested Design Criteria: Minimum Acceptable
Passenger Requirements		
(a) Exterior Appearance	Blends into airport architecture and aircraft environment.	
	Integration of colours, surface textures and structural components.	
	No sharp corners or overhanging structures.	Corners or overhanging structures are mitigated.
(b) Passenger Physical Comfort	All components of the device which physically come in contact with the passenger should be covered or padded.	Major components which come in contact with the passenger should be padded.
(c) Passenger Psychological Comfort	The disabled passenger will be treated in the same manner as other passengers.	The disabled passenger will not feel stigmatized or embarrassed about using the device.
(d) Level of Effort Required for Transfer	Minimal (unassisted).	Medium - 1 person assisting.
(e) Ascending and Descending Acceleration	Gradual acceleration (not to exceed 90 cm/sec^2 ramps not to exceed 1:12 gradient).	
(f) Vibration of Passenger Seat	No significant vibration.	Minimal vibration.
(g) Noise Levels During Operation	Comparable to light traffic at 15 m, may be considered intrusive (maximum 60dB).	Comparable to highway traffic at 15 m, telephone difficult to use (maximum 70dB).
(h) Climatic	Provide complete passenger protection from the elements (comparable to loading bridges).	No risk or injury as a result of exposure to the elements (comparable to current passenger protection).

CHAPTER 4: CONCEPTUAL DESIGNS

Several conceptual designs have been developed using the constraints and criteria presented in Chapter 3. Though they are meant specifically for small aircraft, some application to larger aircraft may be possible. The level change designs are considered as options for advanced concept study, and are grouped into three categories.

Loading Bridges

Option 1: Low Level Loader - Partial Bridge
Option 2: Low Level Loader - Full Bridge
Option 3: Portable Switchback Ramp

Platform Lifts

Option 4: Central Elevator
Option 5: Adjacent Elevator
Option 6: Stair Glide
Option 7: Stairamp

Independent Vehicles

Option 8: Mini-Shuttle
Option 9: Forklift/Pallet

A summary of the attributes of the conceptual designs are as follows.

- A Specialized Boarding Chair is envisioned and meant to operate with any of the level change concepts. The Boarding Chair is included in each of the options.
- The loading bridge and platform lift concepts improve rather than impede the regular flow of passenger traffic by integrating mobility impaired and able-bodied requirements.
- The concepts allow for many aircraft configurations, including consideration of tarmac to door sill height, door position, stair configuration, etc.
- Implementation of the concepts requires no alterations to existing small aircraft.
- Variations of the concepts may be adapted to airports with different operating procedures and sizes.

The design concepts are described in the following sections. Note that these designs are truly conceptual in nature, and require further development as recommended in Chapter 5.

4.1 LOADING BRIDGES

Low Level Loader (Partial and Full Bridge) (Options 1,2)

The Low Level Loader Bridge concept is based on the use of semi-permanent ramps or walkways centred in the parking area for small aircraft at the airport. The walkways would be built in modules, with movable end sections that could be adjusted to properly interface (sideways, up or down) various aircraft types.

The Low Level Loader is thought to have potential particularly because it would:

- o be relatively simple, and thus inexpensive;
- o provide weather protection;
- o access several aircraft parked in the proximity;
- o have little moving equipment and;
- o accommodate and benefit all passengers, including mobility impaired, wheelchair and able-bodied persons.

Operational matters must be reviewed, such as interruption of the free flow of ground side vehicles, the time taken to deploy and the range of parking positions to be supported by one Low Level Loader. Considering the distances between parked airplanes, the concept should require a long structure to reach more than one aircraft on the tarmac.

Figure 4.1 displays the Low Level Loader - Partial Bridge concept. The pivot point between sections should be anchored into the tarmac or have a stable locking mechanism. The ramps would have a grade no greater than 1:12, and the final section which interfaces with the aircraft should be self-levelling.

The bridge sections could be moved manually by ground crew, by attaching them to a ground side vehicle such as a forklift, or by built-in drive units on the wheeled pivot points.

The Low Level Loader - Full Bridge concept is shown in Figure 4.2. Some airports may be able to accommodate the intermediate level lounge built into the terminal building. In this case, all passengers would be able to avoid going outside onto the tarmac when boarding.

Portable Switchback Ramp (Option 3)

The portable switchback ramp concept is shown in Figure 4.3 (The guard rails are not shown to simplify the sketch). The device consists of several lengths of ramp that connect with transfer landings. The final landing at the aircraft door allows minor adjustments in height. The ramp device can be maneuvered manually when

positioning it at the aircraft door. No drive units are required. The ramp folds into itself so that the first ramp level folds under the second, the second under the third, etc. In this way, the ramp device becomes a compact unit for storage and towing purposes.

Figure 4.1: Low Level Loader - Partial Bridge

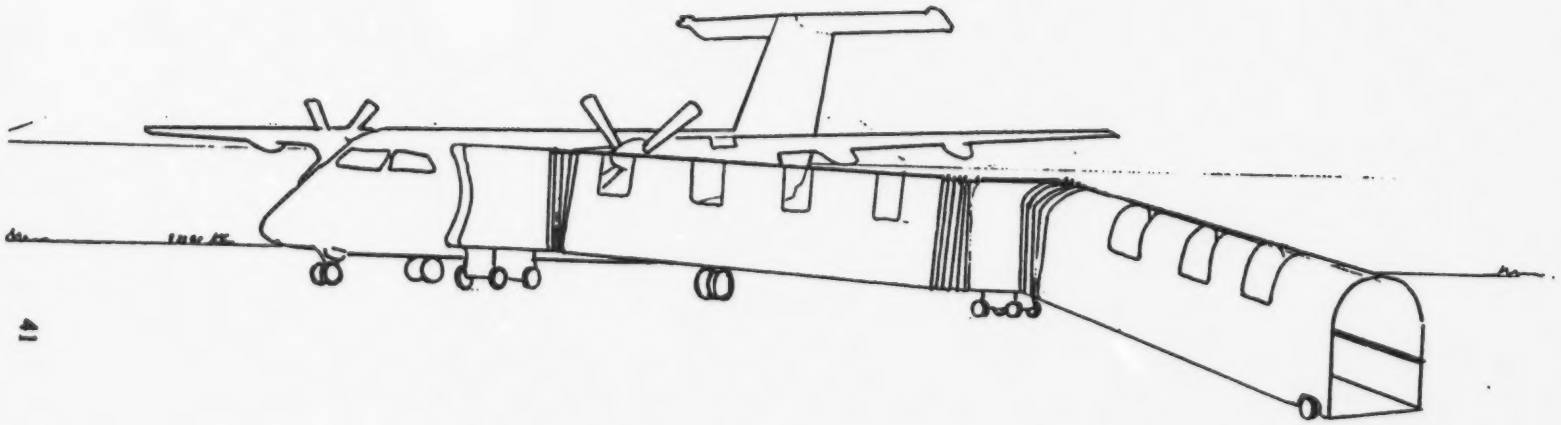


Figure 4.2: Low Level Loader - Full Bridge

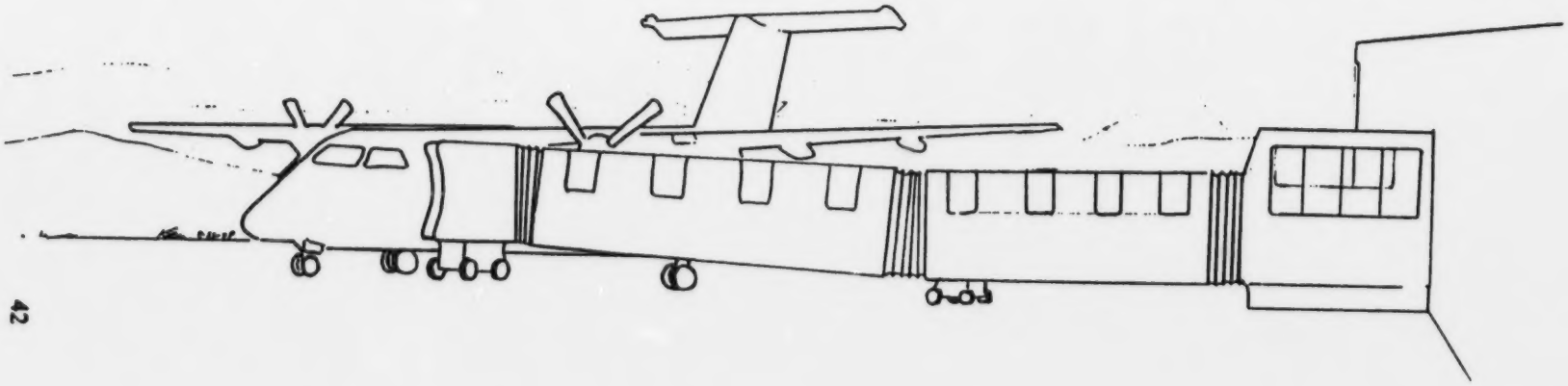
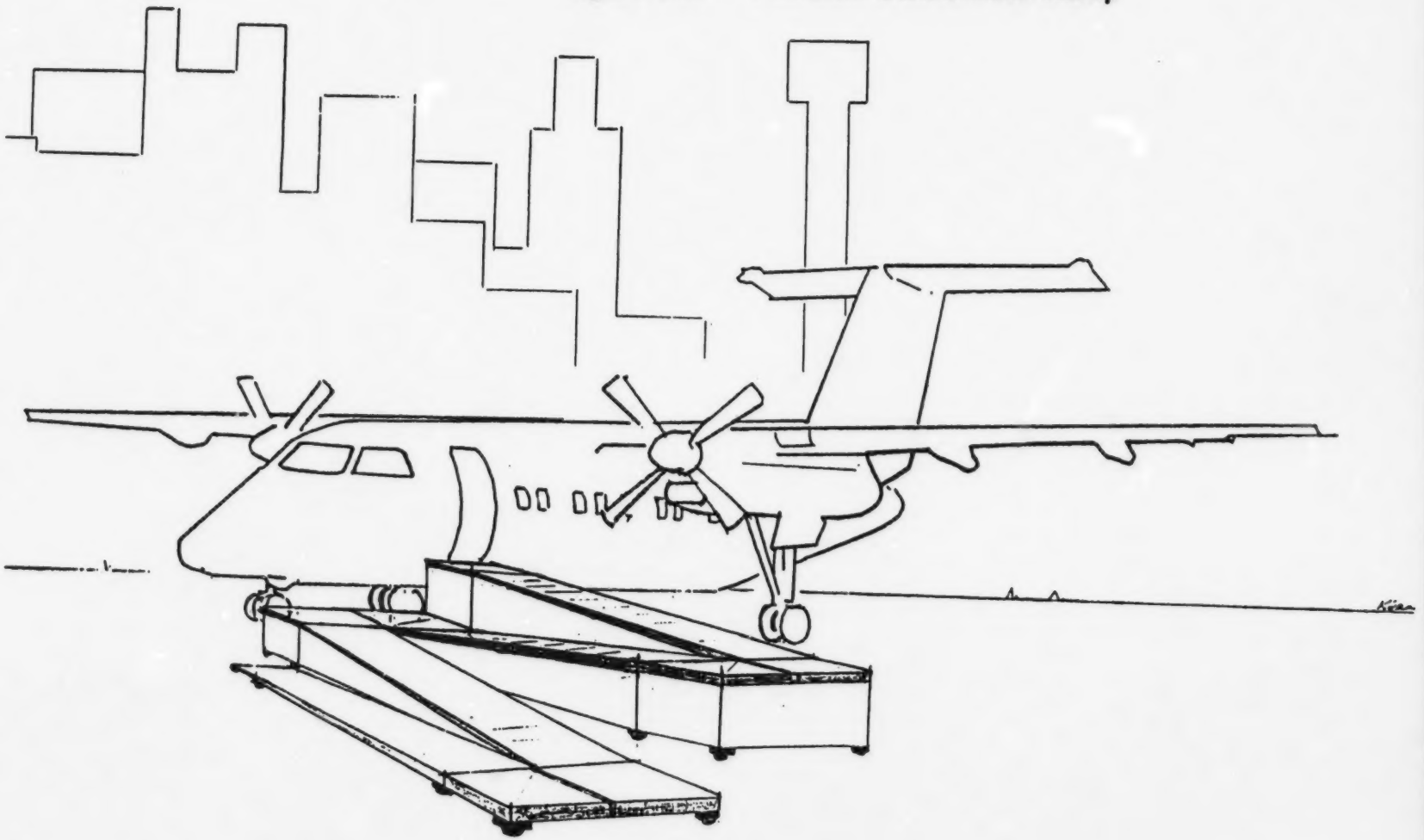


Figure 4.3: Portable Switchback Ramp



Guard rails not shown for clarity.

4.2 PLATFORM LIFTS

The platform lift concept involves the use of a moveable platform which can be raised to various heights and accessed by a combined lift/stair attachment. The stairway would be safer and easier to use than many existing airstairs, especially for elderly passengers and those with luggage and children. The platform would be raised via a hand crank (scissor jack), existing forklift, or a comparable means. Several variations of the platform lift were developed, including the Central Elevator, Adjacent Elevator, Stair Glide and Stairamp.

Central Elevator (Option 4)

Figure 4.4 presents the central elevator variation of the platform lift concept. Mobility impaired passengers will enter the elevating platform from ground level. Once the platform is elevated to full height, it provides a stair landing for regular passenger traffic. This would have the advantage of speeding turnaround time since there is no intermediate re-positioning of boarding equipment. The central elevator is shown with an all-weather cover in Figure 4.5.

Adjacent Elevator (Option 5)

The adjacent elevator is similar to the central elevator, but has the elevating platform on the side of the stair unit as shown in Figure 4.6. Placing the elevating unit on the side allows flexibility in terms of using different elevating methods. For example, a carrier may wish to use a forklift and pallet device in conjunction with the stair unit. The device may function as a stair unit, even without the elevating platform.

Stair Glide (Option 6)

The stair glide concept is shown in Figure 4.7. When the platform is in the down position, regular passenger flow is allowed. The platform remains horizontal throughout the lift process. The landing portion of the device can be raised and lowered to account for varying tarmac to door sill height among small aircraft. The bottom stairs are foldable and the appropriate number may be used when required. The end ramp off the landing may be inclined slightly up or down, depending upon the aircraft door height in relation to the landing height.

Stairamp (Option 7)

The Stairamp scissor lift concept combines a ramp, stairs and elevating platform. The device in ramp position is shown in Figure 4.8. Mobi'ity impaired passengers wheel or walk up the ramp and onto the platform. The platform is elevated by the scissor lift to the level of the aircraft door. When elevated, the ramp becomes a stairway (also shown in Figure 4.8). Able-bodied passengers may then climb the stairs and cross over the elevated platform to enter the aircraft.

The number of steps used depends upon the height of the aircraft door from the tarmac. The number of steps provides a gross adjustment by altering the total lift height by the height of the step. The ramp from the platform to the aircraft door allows for the fine adjustment in height.

The conversion of the ramp to stairs can be achieved through the use of hinges, slotted bars and fixed horizontal distance between the platform and the bottom of the stairs. Investigation of the principles involved in escalator technology will aid detailed design.

Figure 4.4: Central Elevator

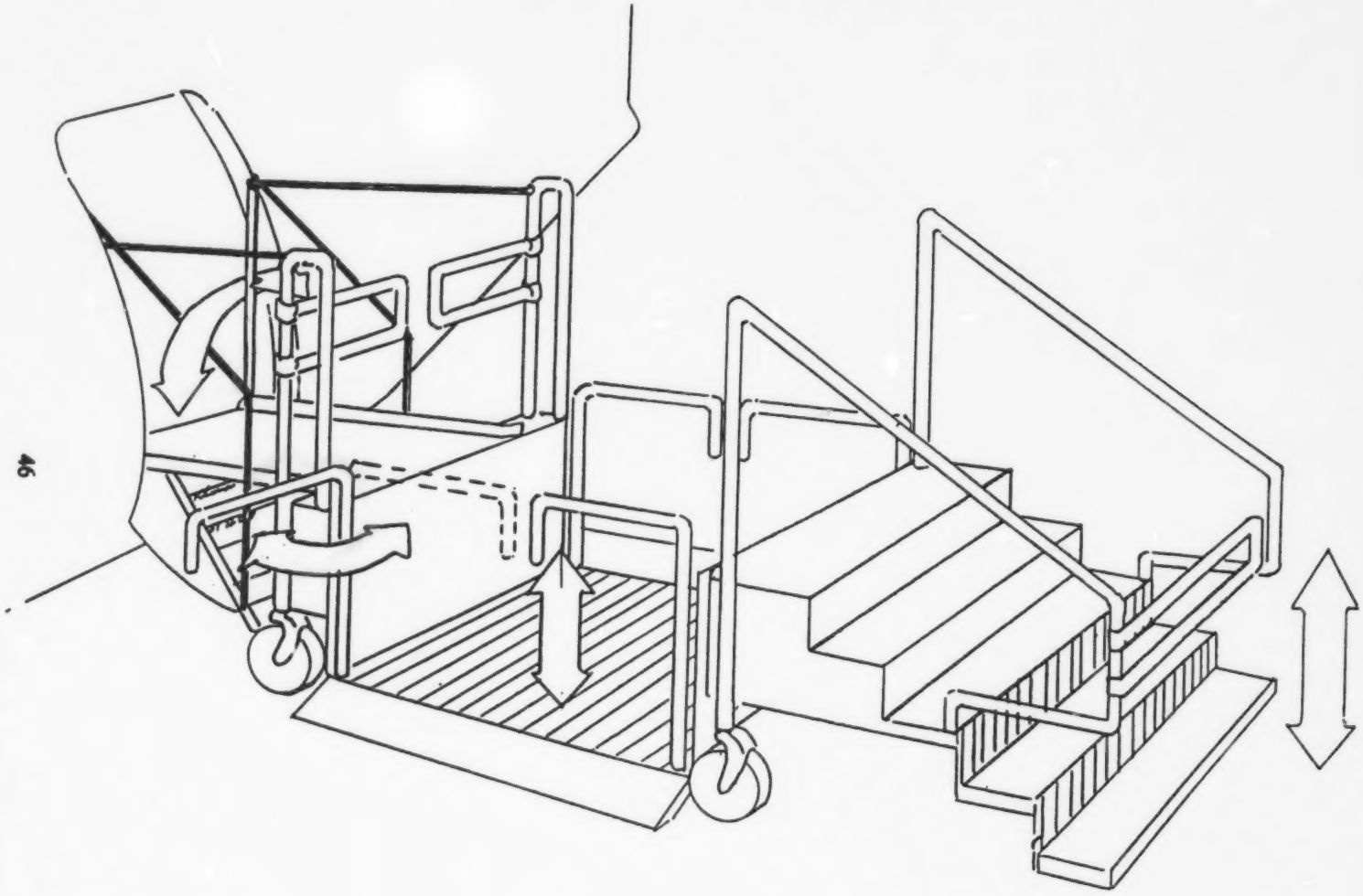


Figure 4.5: Central Elevator with All-Weather Cover

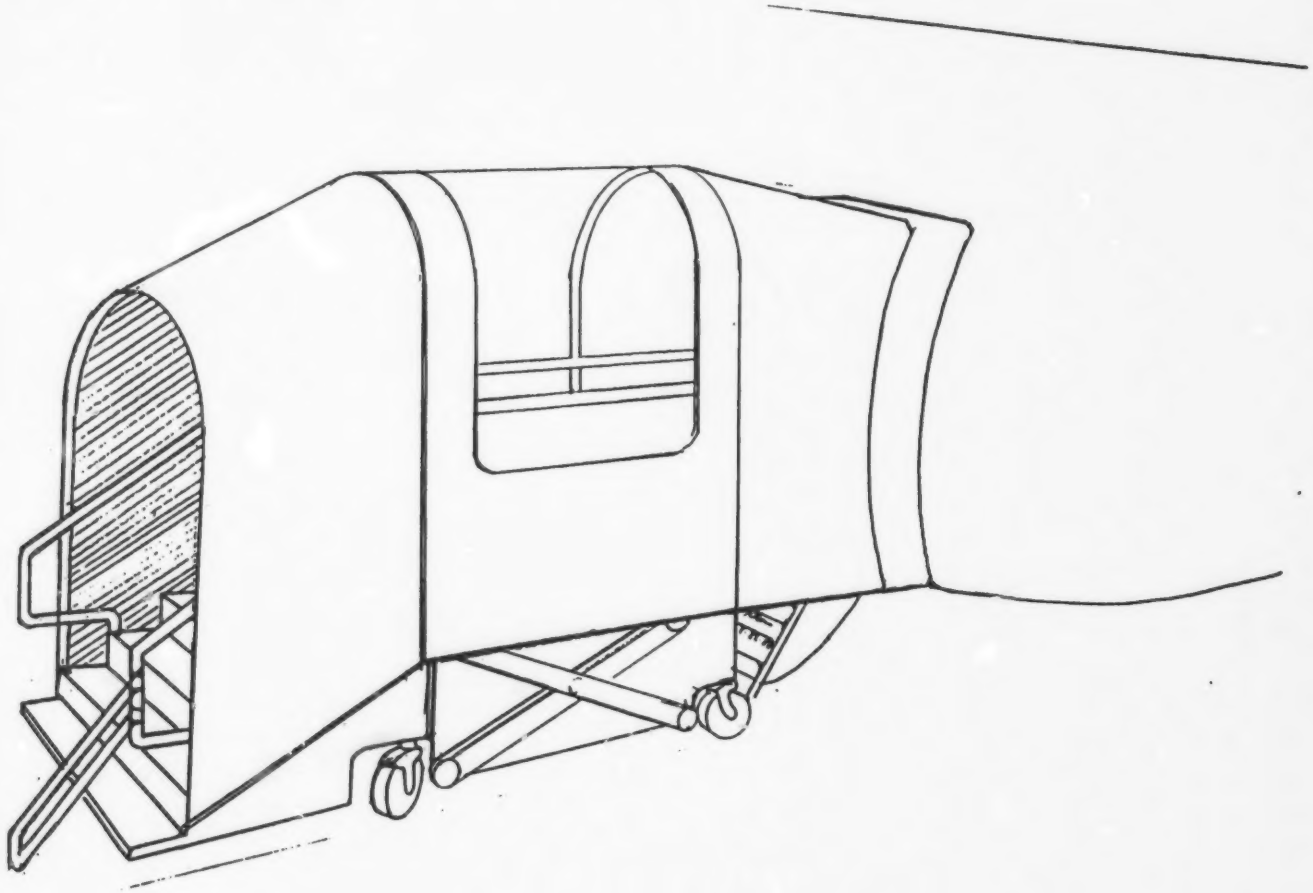


Figure 4.6: Adjacent Elevator

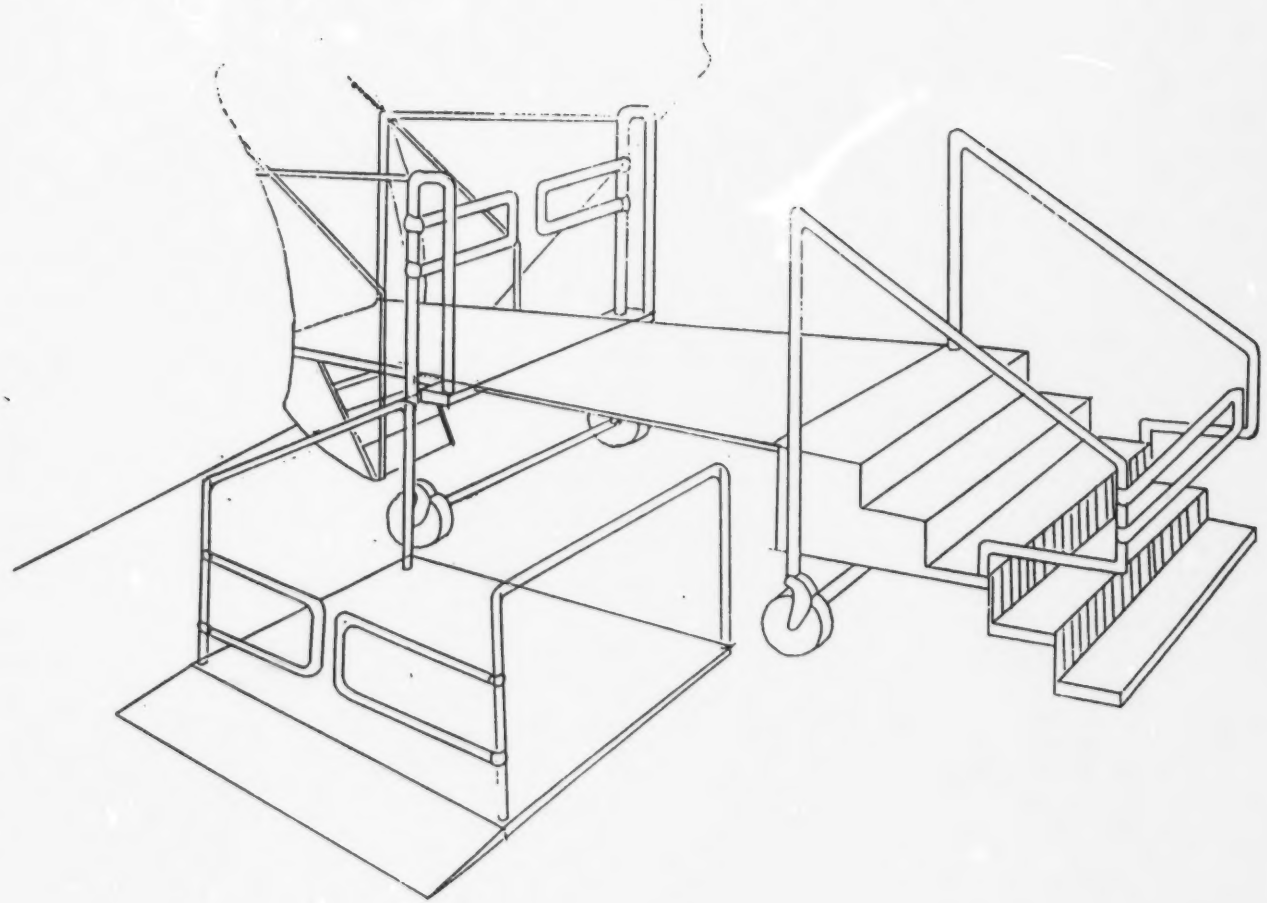


Figure 4.7: Stair Glide

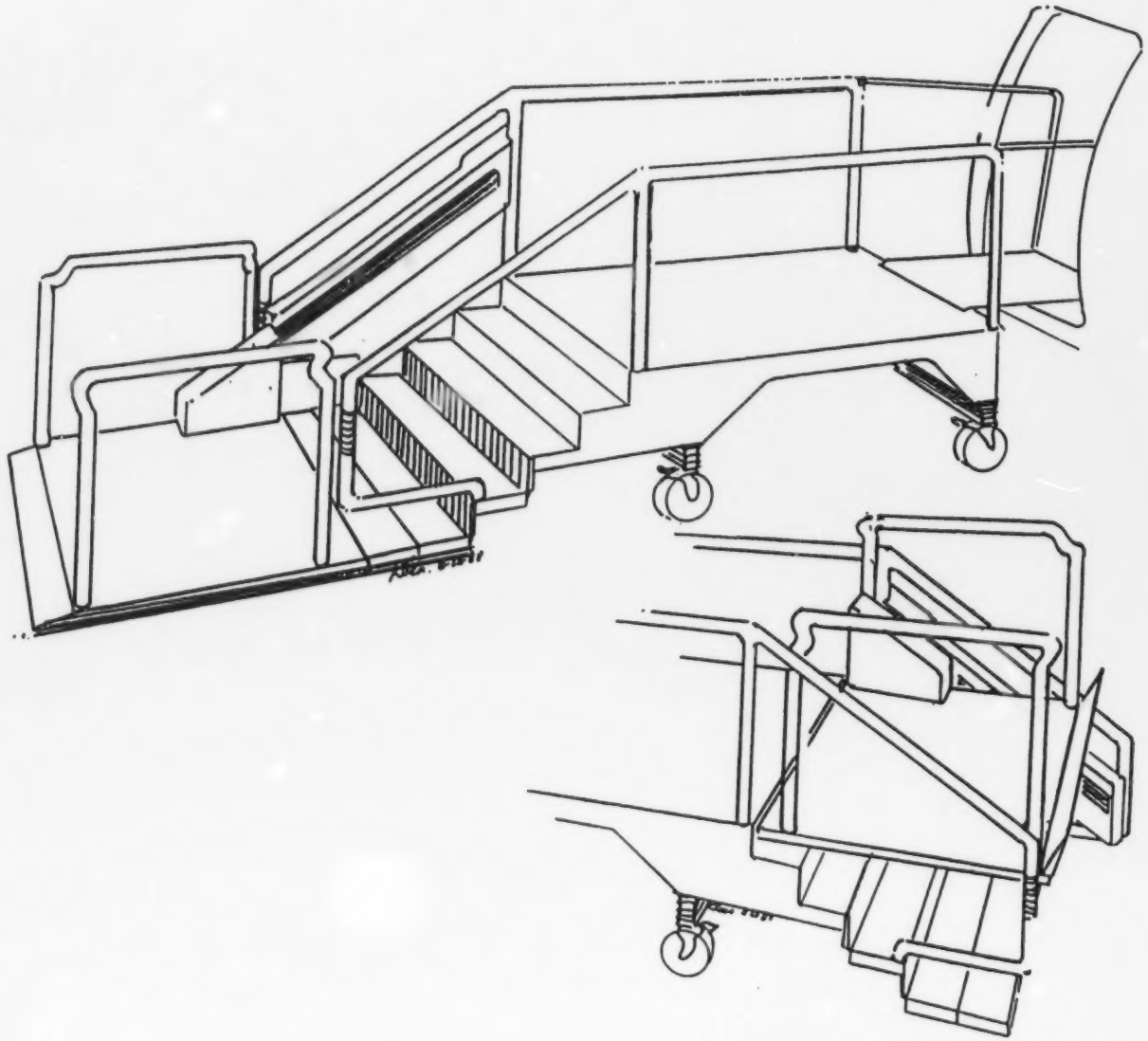


Figure 4.8: Stairamp

4.3 INDEPENDENT VEHICLES

Mini-Shuttle (Option 8)

The Mini-Shuttle option is shown in Figure 4.9. This design could be used in cases where a ramp is inconvenient or could interfere with ground service operations. The shuttle could be moved manually by ground service personnel, or be self-powered. The lift mechanism is scissor-based and self-powered. The operational problems of similar concepts for large aircraft at airports such as Mirabel should be considered in the detailed review of this variation.

Forklift/Pallet (Option 9)

The forklift/pallet concept is already in use in some small and large airports. It is mostly used as an alternative to manual lifting. The pallet is usually specially designed to carry passengers, with guard rails, hand holds, wheelchair restraints and fold down flaps. This concept is often used because of the common availability of forklift trucks among ground side vehicles.

Figure 4.10 displays the forklift/platform in use. Passengers would be loaded onto the platform in front of the aircraft and raised by the forklift. The ramp would then be lowered to the aircraft door to allow access.

Figure 4.9: Mini-Shuttle

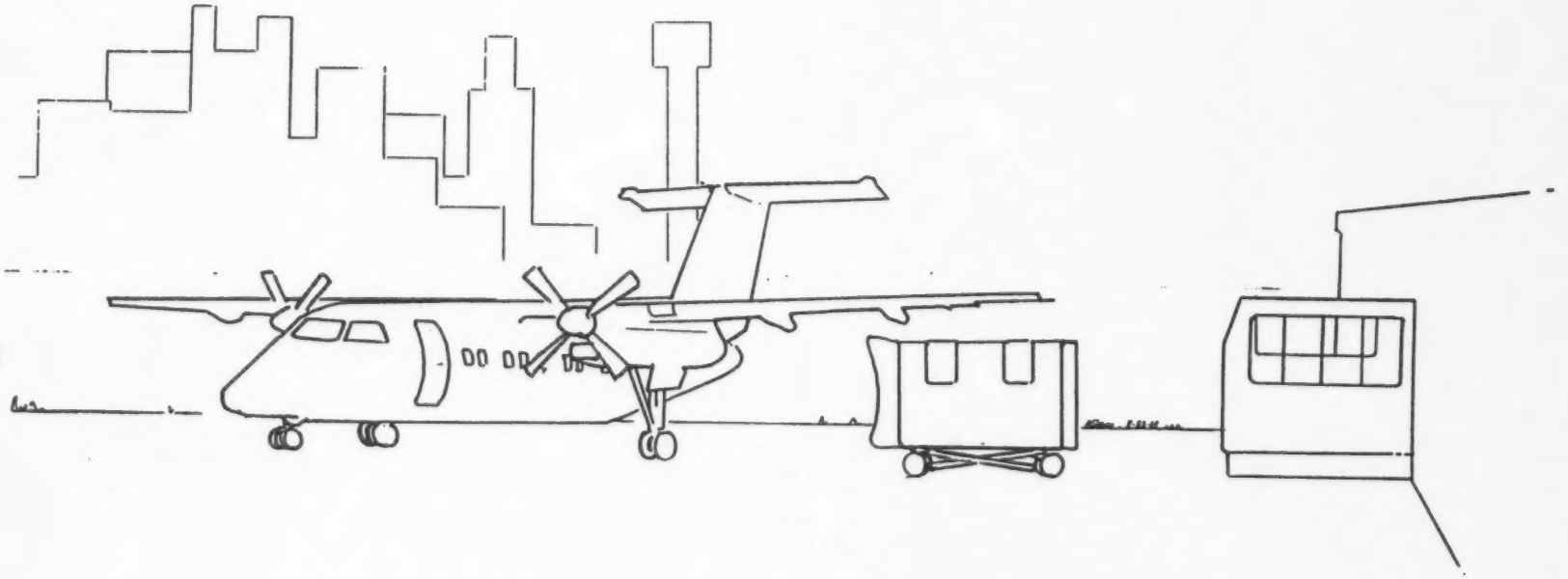
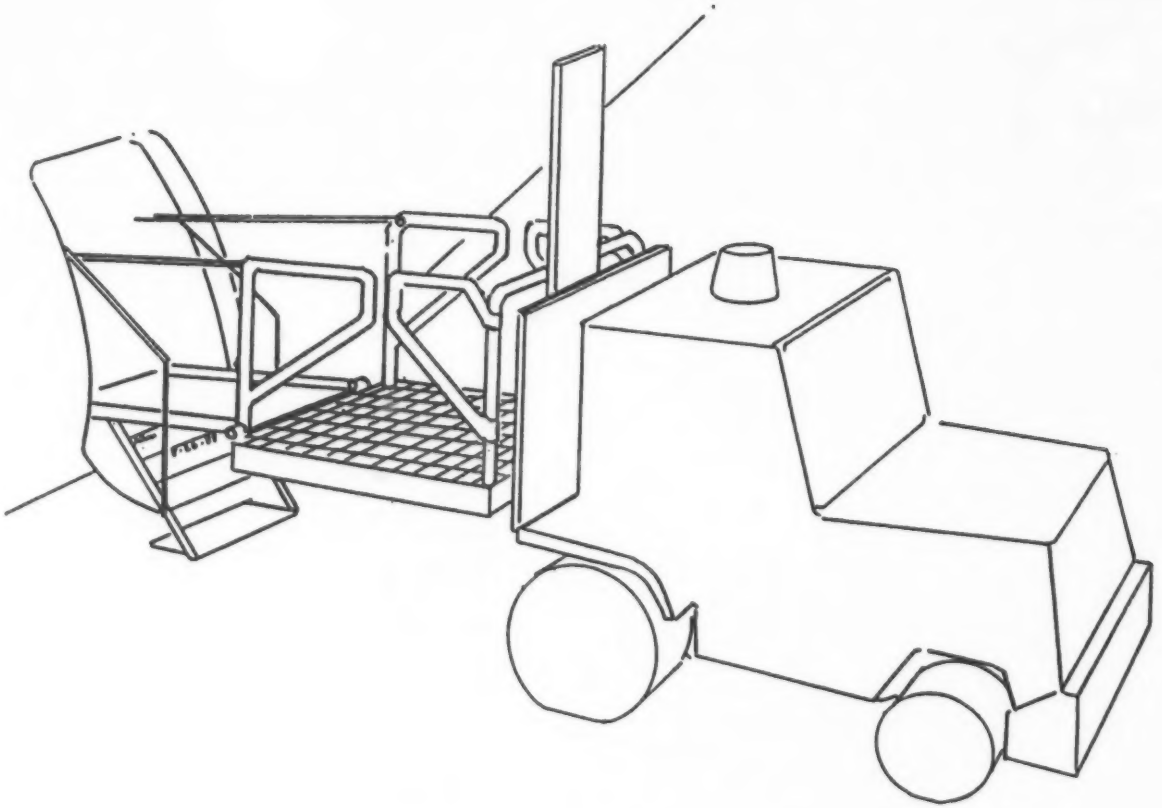


Figure 4.10: Forklift/Pallet



4.4 SPECIALIZED BOARDING CHAIR

The main purpose of the Specialized Boarding Chair is to enable passengers to move the entire distance from inside the terminal to their seats in the aircraft without an intermediate transfer. The chair is adjustable in width so that it can pass down the narrow aisle of a small aircraft but be widened for increased stability outside the aircraft. It is also adjustable in height; upwards to enable passage down the aisle above the height of the armrests, and downward for stability and to enable transfers to and from the aircraft seat. Four variations on these concepts have been developed.

The first variation is shown in Figure 4.11. The unit height and width adjustments are achieved independently. As noted, both adjustments are mechanically aided to reduce operator effort.

The second variation involves the use of additional wheels as stabilizers or outriggers as shown in Figure 4.12. This configuration may simplify the width adjustment mechanism.

Figure 4.13 displays the third variation in which the height and width adjustments are operated by a single control. Thus, increasing the width will also decrease the height and decreasing the width will increase the height. This mechanism is not as flexible as the variations described previously, since the base width will always have to be decreased when traversing a narrow aisle, regardless of the arm rest heights.

The fourth variation, shown in Figure 4.14, involves height and width adjustments of the base only, with a detachable seat. This configuration can be fitted with outriggers and has all of the advantages of the other variations. In this case, there is an additional feature of being able to transfer passengers to the aircraft seat without removing them from the boarding chair seat. This modular design would also allow different types of seats with various features and levels of sophistication to be used with the same base unit.

For all of the Specialized Boarding Chair variations further study needs to be made in the following areas.

- To determine optimum seat width, a compromise between the aisle-width constraint and passenger comfort must be made.

- Determination of wheel size and design must be made keeping in mind the fact that the boarding chair may be required to roll over difficult tarmac surface conditions such as snow and ice.

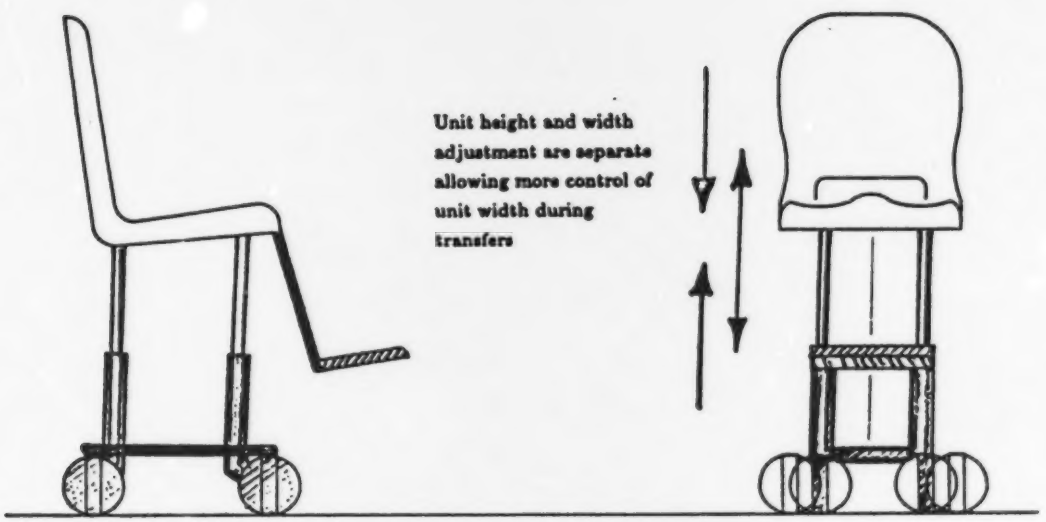
- Raising the seat above the height of the arm rests also raises the centre of gravity of the passenger and chair. The stability of this configuration is questionable, especially since the wheel base width will probably be decreased to enable traversal of the narrow aircraft aisle. Though this is of some concern, the aircraft seats themselves may provide some support to the passengers as they move down the aisle. When the chair is stopped and the transfer to the aircraft seat performed, the outrigger wheels can be deployed to increase the chair stability.

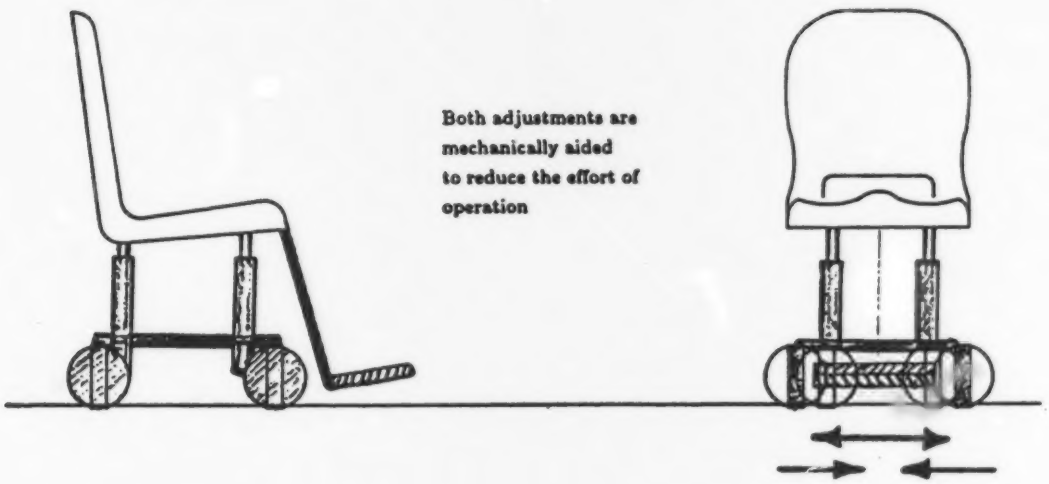
- Mechanisms to ease the lateral transfer of the passenger from the chair to the aircraft seat should be explored.

- Some small aircraft have low cabin heights; therefore, raising the boarding chair above the level of the arm rests may not be possible. For example, the sitting height from buttock to head of a 50th percentile man is approximately 36 inches (9i cm) [11]. When this height is added to a typical armrest height of 22" (56 cm), the overall height of the seated passenger becomes 58 inches (147 cm). The Twin Otter and Metro III have cabin heights of only 59 and 54 inches (150 and 137 cm) respectively.

- Many carriers have already invested in some form of boarding chair, and will be reluctant to purchase another. Marketing the advantages of this chair and cost of production must be carefully considered when pursuing this concept.

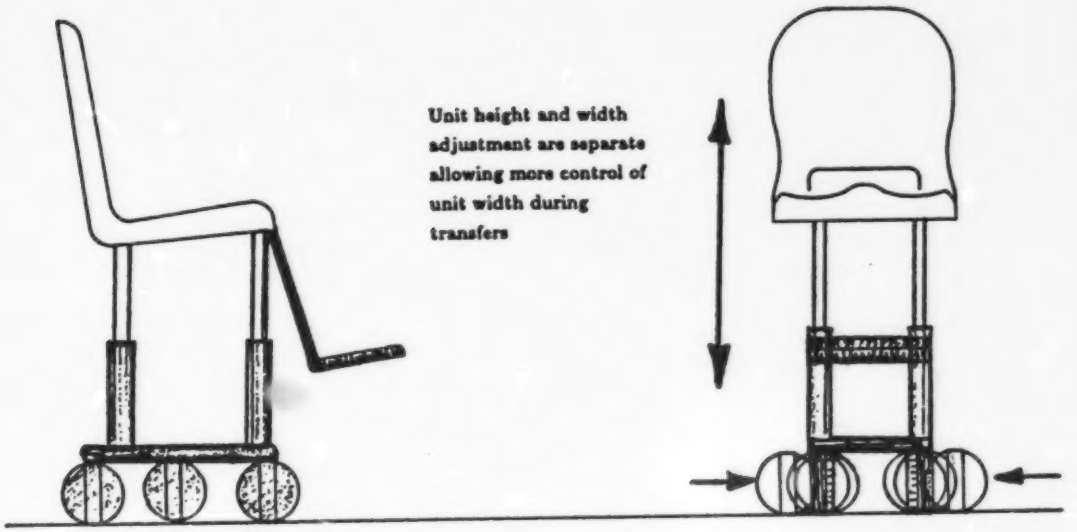
Figure 4.11: Boarding Chair - Variation I

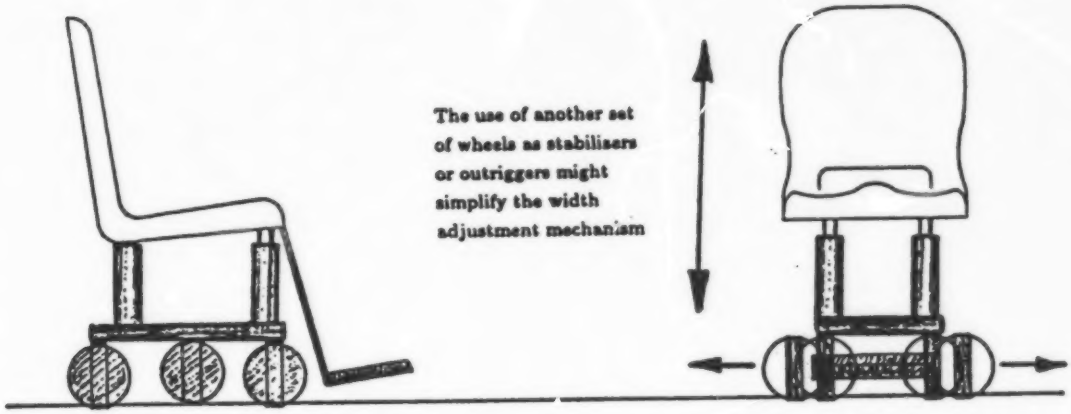




Shoulder and lap belts not shown for clarity

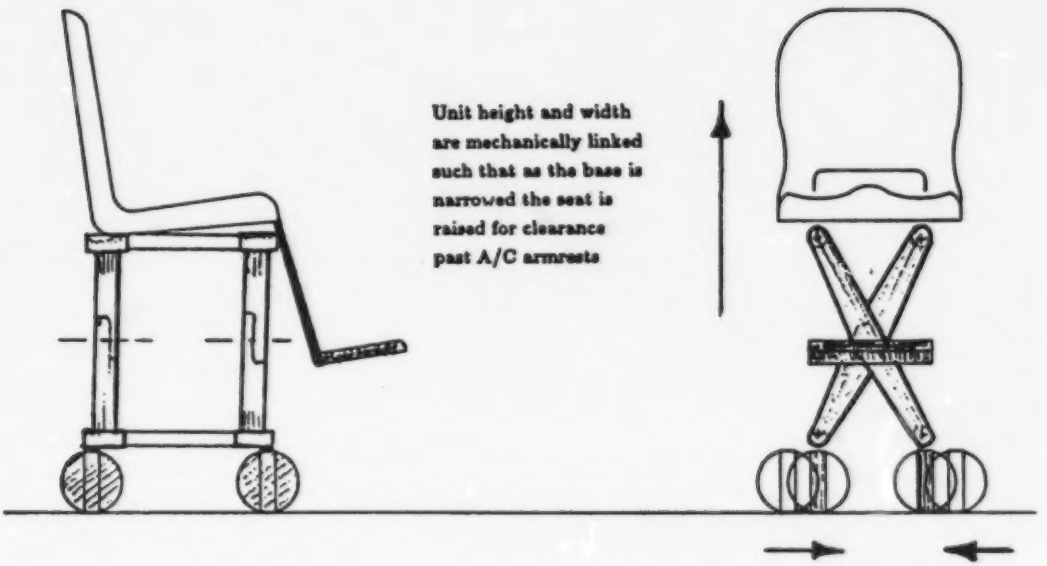
Figure 4.12: Boarding Chair - Variation II

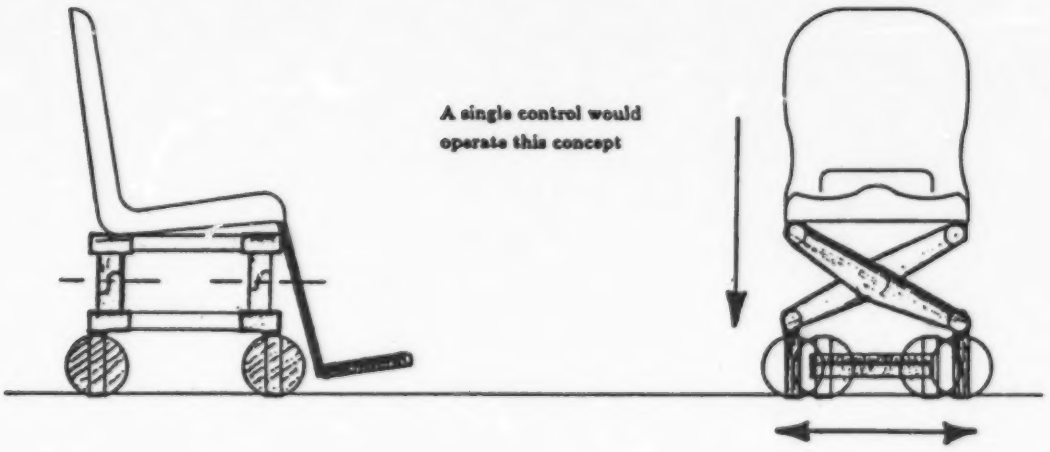




Shoulder and lap belts not shown for clarity

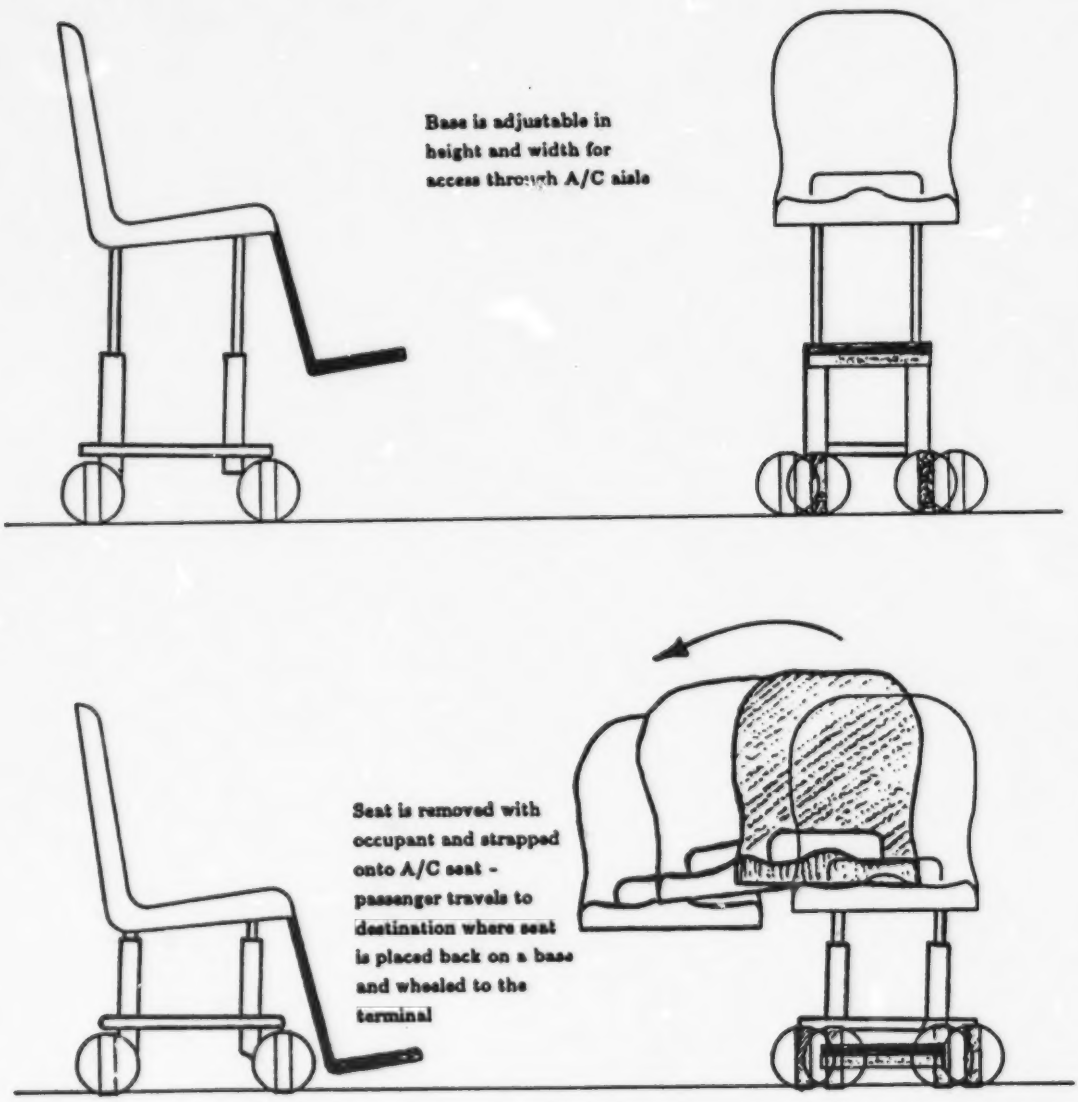
Figure 4.13: Boarding Chair - Variation III





Shoulder and lap belts not shown for clarity

Figure 4.14: Boarding Chair - Variation IV


Base is adjustable in height and width for access through A/C aisle
Seat is removed with occupant and strapped onto A/C seat - passenger travels to destination where seat is placed back on a base and wheeled to the terminal

Shoulder and lap belts not shown for clarity

4.5 EVALUATION OF CONCEPTS

The evaluation methodology developed in Chapter 3 provided the basis for comparison of the relative performance of the nine small aircraft level change concepts described in Sections 4.1 through 4.4.

It should be noted that due to the conceptual nature of the nine options, several of the design criteria identified in the evaluation sheet will not apply until the concepts have been further refined by the design process.

The results of the evaluation performed by the project team are shown in Appendix H. The ranking of the nine options is as follows.

(1) Option 2: Low Level Loader - Full Bridge
(2) Option 1: Low Level Loader - Partial Bridge
(3) Option 7: Stairamp
(4) Option 4: Central Elevator
(5) Option 6: Stair Glide
(6) Option 5: Adjacent Elevator
(7) Option 3: Portable Switchback Ramp
(8) Option 8: Mini-Shuttle
(9) Option 9: Forklift/Pallet

The evaluation of the options at a conceptual level does not identify a single, preferred solution from the nine options. It does provide a relative comparison of the attributes and disadvantages of the families of options.

The **Low Level Loader** family of loading bridges rank the highest according to the design criteria and should be pursued in advanced concept study.

The Portable Switchback Ramp option is also a member of the loading bridge family, but has a relatively low ranking in comparison to the other options. This low ranking was due to the following difficulties.

- The ramp necessary to make the level change at the recommended slope requires too many landing transfers that must be performed in a confined space. The boarding process would be lengthy and laborious for both wheelchair users and other mobility impaired persons.

- When unfolded for use, the ramp takes up a lot of space on the tarmac. For some aircraft, it may interfere with the propellers or tail.

- The portable ramp would likely discourage able-bodied users, considering the necessary ramp length and switchbacks.

The **Platform Lift** family of options is the next most promising in terms of the evaluation rankings. Although the Stairamp option is technically complex, it ranks high because it can be manually operated and allows access by both able-bodied and mobility impaired passengers. Design difficulties are anticipated in ensuring proper and reliable operation and orientation of the stairs. The remaining platform lift

options have similar evaluation scores and are closely ranked. Each of the options is recommended for advanced concept study.

The Independent Vehicles family of options rank last according to the evaluation criteria. The Mini-Shuttle option has a reasonable score and may be appropriate for large airport application.

The Forklift/Pallet is not recommended for further concept study. This option received a "zero" score on the Physically Integrated Systems criteria (Design Element - Functional Adequacy (d)) which eliminates its validity. Further difficulties for this option are as follows.

- Forklifts are usually used for loading baggage or other goods, not passengers. Wheelchair users who are loaded in this way may feel stigmatized in being handled like cargo.

- For practical purposes, forklifts are used for wheelchair passengers and their attendants only. They will not benefit the frail, elderly and other mobility impaired.

- The forklift/pallet process impedes the regular flow of passengers. The forklift and pallet must be set up and removed before able-bodied passengers can proceed.

- The forklift is a common piece of ground equipment at larger airports. Its availability makes it a good candidate for use in the boarding procedure. Forklifts are available from numerous manufacturers, however, and a wide variety of them will exist from airport to airport. This is important as the stability of the boarding device may depend upon the forklift. Special consideration must be given to the adaptability of the pallet unit to different types of forklifts.

- Forklifts are not designed for carrying passengers. The ride can be rough, and vertical positioning jerky, making passengers insecure.

The application of the two recommended families of concepts may depend on the size and operating characteristics of the airports and carriers to be served and ultimately the cost of purchasing and operating the device.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

This chapter draws conclusions from the work of the project. The first section summarizes the current situation, the need for improvement, and the design guidelines for such improvements. The second section is an evaluation of the design concepts. The last section outlines an overall strategy and recommendations for the development of selected concepts.

5.1 THE OVERALL NEED

User Characteristics and Market: Mobility impaired travellers encounter difficulties at all stages of a small aircraft journey, including boarding and disembarking, moving about in the terminal, and on-board seating. The level change (from tarmac to aircraft floor) is the most obvious barrier to wheelchair users. However, there are ten times more mobility impaired individuals than wheelchair users. For the less severely disabled and the frail elderly, the walking distances can be prohibitive. Solutions should therefore address the broadest range of mobility disabilities.

The current ridership on small Canadian aircraft is estimated at 13 wheelchair passengers per week (across the country) and 300 mobility impaired passengers per week. With the development of appropriate assistive devices and the elimination of other barriers (such as income and employment), ridership could be increased by more than tenfold, to 300 wheelchair passengers per week and 4,000 mobility impaired passengers per week. (This is the "barrier-free" model.)

Personal Mobility Aids: Storage of mobility aids is a major concern in air travel, and especially problematic in commuter aircraft. In the smallest aircraft, storage of wheelchairs is physically impossible. In the twenty-seaters, luggage must be carefully arranged for fit and centre of gravity, prompting many carriers to request advance notice. The potential for storage problems becomes more acute during interlining, when a traveller transfers to a small aircraft.

Specialized boarding chairs have been developed for use in large aircraft, but are too wide for the typical commuter aircraft aisle. A new chair must be developed. Ideally this chair would serve the user for his/her movement from the waiting room to aircraft seat, reducing the number of transfers required.

The timing of the transfer from the individual's wheelchair into the carrier's specialized chair is critical. Individuals prefer to transfer as late as possible in the process (for comfort); airlines prefer the transfer as early as possible (to facilitate storage of the individual's wheelchair).

Aircraft Characteristics: There are a number of different small aircraft operating across Canada, with a variety of physical barriers to disabled users. The primary challenges include: the air-stairs (including supports), door widths, vestibule configurations (i.e. turning a wheelchair inside the aircraft), aisle widths, and the armrests on seats.

Six small aircraft which are expected to be in common use within the next five years are representative of the above critical factors. They are the Cessna 402, Dash 8, Twin Otter, Convair 580, Jetstream 31 and Metroliner III.

Current Practice: Small aircraft are often parked away from the terminal building and at "the far end", causing a long and difficult walk or ride for mobility impaired travellers. The smaller Canadian carriers currently use whatever means available to board wheelchair travellers. This includes manual lifting, a forklift and pallet, or the high-backed wheelchair used in large aircraft. At small airports resources are scarce, and it is often the ticket agent or pilot who assists the passenger. The safety of some of these approaches is a real concern. At times service is even refused.

The issues of designated seating for, and quotas of, disabled passengers are unresolved. The real safety implications are not clear. In practice, it is a judgement call by the carrier.

There are several lifts and level-change devices on the market, some built for large aircraft. None of these is appropriate for commuter-type aircraft. However, two Canadian (and at least one U.S.) manufacturers are developing prototypes. In addition, the U.S. Federal Aviation Administration (FAA) has a program underway to sponsor the development of a level change design for aircraft.

A Design Evaluation Framework: The major factors influencing the design of an accessible system for small aircraft are summarized as follows:

- Minimize transfers. Integrate a specialized, on-board wheelchair into the concept;
- Facilitate wheelchair storage;
- Account for weather (especially ice, packed snow and cold);
- Provide for the free flow of all passengers. Facilitate (rather than inhibit) the flow of able-bodied travellers;
- Ensure negligible modifications to the actual aircraft;
- Ensure simplicity of design and operation;
- Consider different solutions for different airport sizes. Consider variations in budgets, staff and existing equipment; and,
- Consider the capital cost, especially the constraints of the smaller carriers.

These and other factors have been synthesized into an evaluation framework. The factors are defined in terms of specific criteria, and are grouped according to: safety, functional adequacy (operations, portability, climate, etc.), technical requirements (standards, dimensions, design life, maintenance, etc.), and passenger comfort. Each criterion has a "minimum acceptable" and "ideal". A weighting and scoring system is applied to ensure all factors are considered, and to allow for comparison of design concepts.

5.2 CONCLUSIONS FROM THE CONCEPT EVALUATIONS

Evaluation: The project team has developed and evaluated nine concepts and variations. Evaluation of the concepts revealed the following conclusions:

- The low level loader bridge concepts rate very high, and should be pursued.
- The platform lifts rate well, and all variations should be pursued. The stairway scissor lift gets similar scores, and should be pursued with this "family" of concepts.
- The mini shuttle concept gets mixed reviews, and should be pursued only as a special concept for large airports.
- The portable (switchback) ramp concept gets mixed reviews, and generally lower scores than the low level loader bridge. It should therefore be dropped from further consideration.
- The forklift pallet concept receives low scores, and should be dropped from further consideration.

The Preferred Concepts: The two concepts of greatest potential are a "low-level loading bridge" and a "platform lift". Both of the concepts are simple, easy to operate, and enhance (rather than impede) the flow of all passenger traffic. They are compatible with a majority of the small aircraft currently used in Canada.

The loading bridge is based on the jet-way concept. It involves the use of semi-permanent ramps or walkways extending from the terminal into the centre of the aircraft parking area. The walkways are built in simple sections, possibly with weather covers. The end sections are moveable such that they may be pivoted (horizontally or vertically) to butt up against various aircraft. Manual operation is quite feasible. Interference with ground-side traffic is one potential drawback.

The platform lift concepts employ a portable stairway system with an integrated lift. The wheelchair traveller uses the lift to get to the aircraft door height. Able-bodied passengers then board via stairs (which are part of the device), without a need to move the device. The lift can be powered by a manual scissor jack, an existing forklift or comparable means.

Specialized Boarding Chair: The aisles of small aircraft are extremely narrow; some as narrow as 11 inches. Current boarding chairs used for larger aircraft, are too wide. For this reason a new specialized boarding chair is required.

Both of the selected concepts above assume the use of a specialized boarding chair, developed in tandem with the concepts. The chair is meant to be used on the level change device, and in the aircraft aisle to the passenger's seat, thus minimizing transfers.

5.3 RECOMMENDED APPROACH TO FUTURE WORK

Next Steps: The recommended future work falls in two parts: (A) the level change equipment, and (B) the specialized boarding chair. This work should include consultation throughout, with users, Canadian airport staff, small carriers and the

U.S. Federal Aviation Administration (which is running a parallel program). The recommended steps are as follows:

PART A (Level Change Equipment):

- o Investigate the FAA program for lift development. Discuss joint funding of future work.
- o Perform a detailed evaluation of the two selected concepts. Involve operators, airports, policy makers, etc.
- o Develop functional designs for the two selected concepts;
- o Select one concept for detailed design using the evaluation framework developed in this work;
- o Fabricate prototypes; and,
- o Evaluate the prototypes at airports of varying sizes.

Note that one concept may be insufficient for all Canadian carriers and airports. Due to the range in sizes of carriers and airports which have small aircraft, two concepts may be warranted: one for frequent use and one for infrequent use.

PART B (Specialized Boarding Chair):

- o Perform a detailed evaluation of the chair. Involve operators, airports, policy makers, etc. Review the potential market and costs;
- o Develop functional designs for alternative concepts;
- o Select one concept for detailed design;
- o Fabricate prototypes; and,
- o Evaluate the prototypes in real aircraft.

5.4 OTHER FINDINGS OF SIGNIFICANCE

During the course of the work, several items of significance arose, which may warrant future consideration:

- o Difficulties with the stowage of wheelchairs in small aircraft are apparent. The solutions to these difficulties are operational in nature, and thus they are separated from the development of level change equipment.

- o On-line communications between carriers would eliminate surprises during interlining (such as stranding a wheelchair in mid-voyage due to connecting to a smaller aircraft).

- o Small carrier personnel do not deal with disabled passengers frequently and are therefore not used to providing service to them. Introductory training programs consisting of manuals, videos and in-situ demonstrations are recommended, to aid personnel who serve disabled passengers.

REFERENCES

1. "Disabled People Comment on Flying". NINNESCAH. May/June 1986.

2. Dunlop, J., M.D. British Airways, Coping with the Handicapped Air Traveller.

3. NINNESCAH. July/August 1984.

4. Reida, Ellis "Small Airliners", NINNESCAH. Volume 5, Number 6, November/December, 1987. p. 5.

5. Wheelchair Database - RESNA. Scan of Everest & Jennings, Invacare, Theradyne.

6. Wiklund, M.E. "Determining Workable Approaches to Mobility Aids Storage". Ninnescah. Volume 7, Number 5, September/October, 1988.

7. Reida, Ellis. "Small Airliners". NINNESCAH. Volume 5, Number 6. November/December 1987. p. 5.

8. Virellas, Alfred A. "Access Features and Assistive Equipment". PARAPLEGIA NEWS. Volume 42, Number 8. August 1988. p. 49.

9. McCaffery, W.F. and O'Brien, M.G. Aircraft Boarding of Wheelchair Passengers - Phase 2 - Detailed Assessment of Mechanical Boarding Devices. TP7211E, TDC. September, 1985.

10. Devlin, David, Airport Manager, Whitehouse Airport. September 9, 1988.

11. Woodson, Wesley E. Human Factors Design Handbook. McGraw-Hill Book Co. New York, N.Y. 1981.

12. Reida, Ellis "Proposed Regulations". NINNESCAH. Volume 6, Number 4, July/August 1988.

13. National Transportation Agency of Canada, Possible Provisions Pertaining to Air Fares for Assistants of Disabled Persons, and for Additional Seats Required by Disabled Persons. Ottawa, Ontario, 12 May 1988.

14. Statistics Canada, Dept. of the Secretary of State of Canada; Report of the Canadian Health and Disability Survey/1983-1984. (Supplement to the Labour Force Survey); Ottawa, Ontario, published July 1986.

APPENDIX A:

Small Aircraft in Operation in Canada

SMALL AIRCRAFT IN OPERATION IN CANADA				
Aircraft	Pass Cap	MASS (KG) Empty	Max. TO	# of Aircraft	Comments
Beechcraft Hawker Corp.					
18/E18S	7 - 9	2,651	4,400	8	
99	15	2,663	4,944	7	Mainly commuter airliner; narrow stairs not compatible with power boarding equipment.
100				3	
B-80					
Baron	4			2	Light transport airliner.
Baron 58	4 - 6	1,490	2,449	1	Business & executive aircraft.
Duke A-60	4 - 6	1,939	3,073	1	Business & executive aircraft.
Duchess				1	
KingAir 90	6	2,558	4,377	1	Seats 15 in hi-density layout.
KingAir 100/A100/	6 - 8			4	Seats 13 for commuter use.
200 & C-90				1	
KingAir B-90				5	
QueenAir				5	
QueenAir A65	4 - 6	2,393	3,992	1	
Excalibur 800					
QueenAir B8800				1	
Turbo Tradewind				1	
British Aerospace Inc.					
HS-748	58		17,915	22	Wheelchairs raised up to the wide forward cargo door on forklift, passenger put in first seat.
HS-748-2A	52	12,110	20,182	11	
Britten-Norman					
Islander /2A	9	1,695	2,857	16	"Wall-to-wall" seating with alternating doors along the fuselage.
Pilatus 2A-27	17			1	
Pilatus Turbo Porter	17			1	
Cessna Citation					
177B	4			1	Utility aircraft.
180/182/182RG/185/	6			41	Utility aircraft.
185F/Skywagon/					
Skywagon 180J					
2O6				16	
U206				1	
U206G				1	
UT206				1	
2O7				3	
210/Centurion				2	
210M				1	
3TOR				3	
310/310IIR/310M/310R	4			13	
337/337G	4 - 6			3	
34O	4				
402/402C/411A	9	1,767		24	Business aircraft; 9" aisles.
4O4				4	
404 Titan	6 - 10	2,165	3,705	1	6 - Executive, 10 - Commuter, (including crew)
Citation	6	2,935	5,834	4	

SMALL AIRCRAFT IN OPERATION IN CANADA					
Aircraft	Pass. Cap.	MASS (KG) Empty	Max. TO	# of Aircraft	Comments
Cessna con't					
Citation 500				4	
Citation 501				2	
Citation 550				1	
Citation 650				1	
Cutlass				1	
Hawk XP				1	
Turbo Stationar	6 - 8			1	
Convair					
44O	52	15,110	22,544		Short range airliner.
58O	56		26,371	28	Short range airliner.
64O	56	13,732	24,950	4	
Curtiss Wright of Canada Inc.					
C-46	up to 66	14,970	21,364	5	
de Havilland					
Beaver				2	
Dash-7	48 - 56			16	Boarding chairs fit down aisle.
Dash-8	17			40(30)	Short haul transport aircraft.
Otter				4	
DHC-2				1	Light utility aircraft.
DHC-2 Beaver/Turbo/ MK Turbo	7			44	
DHC-3				3	
DHC-3 Otter	10			12	Utility aircraft.
DHC-3 Twin Otter/300/ -6 Twin Otter	20	3,320	5,670	51	Commuter airliner.
DHC-4 Caribou/4A	30			2	
DHC-6					
DHC-6 Beaver				1	
DHC-6 Otter				1	
DHC-6-200					
DHC-6-300				9	
DHC-6A					
Embraer Aircraft Corporation					
100P1	18			2	
110 Bandeirantes	19 - 21	3,200	5,300	8	Commuter airliner.
Fairchild Aircraft Corporation					
F-27J/FH-227	60	10,399	19,730	7	Good stairs with a spacious landing foyer.
Merlin IIA				1	
Metro II/Merlin IV/IVA	12 or 19-22	3,356	5,670	14	Commuter airliner; very narrow fuselage; greater-than-normal height from tarmac (almost 5 feet).
Merlin Metros				2	Bottom step of 'drop-down' stairs quite high from the ground.
Fokker					
F28-1000	60	16,144	29,480	5	

SMALL AIRCRAFT IN OPERATION IN CANADA				
Aircraft	Pass. Cap.	MASS (KG) Empty	Max. TO	# of Aircraft	Comments
Grumman				
G-73 Mallard				1	
Goose G21A/G21C	7	3,040	5,670	7	Amphibians.
Gulfstream G-159	10 - 19	9,933	15,920	2	10 - Exececutive, 19 - Commuter.
Lear				
35A				2	
McDonnel-Douglas of Canada Ltd.				
DC-3	24 - 28	8,030	11,430	38	
Piper				
Aztec/PA-23-250/31-350/ 32-250C	6	1,442	2,360	24	
Cherokee				6	
Cheyenne	4 - 6	2,209	4,082	5	
Cheyenne III	up to 8	2,550	4,763	1	
Chieftan/PA-31-350 Navajo & Navajo Chieftan	6 - 10	1,886	3,175	21	Business aircraft.
PA-31/310 Navajos	6 - 8			7	Executive and commuter aircraft.
PA-23				1	
PA-23-150				2	
PA-23-250				2	
PA-30/Twin Commanche	4 - 6			3	
PA-31				6	
PA-31-310				2	
PA-31-350				2	
PA-32R-300				2	
PA-34-200/200T/Seneca/ Seneca II	6	1,264	2,073	6	Business and light transport aircraft.
PA-44				1	
T1040	9			1	
Warrior				1	
Rockwell International				
Aero Commander	4 - 7			3	
Commander 840				1	
Saunders				
ST-27				2	
Shorts Brothers (USA) Inc.				
330				1	
360				2	Wide entrance doors; only 4 stairs from tarmac to entrance making it 'generally accessible'.
References: 5 - 8.					

APPENDIX B:

Small Aircraft Fleets of Canadian Air Carriers

NOTE: This list is not necessarily 100% accurate or all inclusive. Information was gathered from a variety of sources, several of them verbal. Further details can be obtained from the carriers or from the Air Transportation Association of Canada (ATAC) in Ottawa.

CANADIAN AIR CARRIERS		
Carrier & Head Office	**Fleet**	**Area of Operation**
AIR CANADA		
Air BC (owned partly by AC) Richmond, B.C.	6 de Havilland Dash-7's, 12 de Havilland DHC-6 Twin Otters,1 DHC-3 Otter, 1 Britten Norman Islander, 1 DC-3, 4 Dash-8-100's, (4 Dash-8-100's), (6 Dash-8-300's).	Dawson Creek, Grande Prairie, Prince George, Quesnel, Williams Lake, Edmonton, Powell River, Kamloops, Kelowna, Calgary, Seattle, Penticton, Vancouver, Victoria, Nanaimo, Port Hardy, Campbell River, Comox, Castlegar, Cranbrook.
Air Nova (owned partly by AC)	4 Dash-8-100's	Goose Bay, Blanc Sablon, St. Anthony, Deer Lake, Gander, Stephenville, St. John's, Sydney, Charlottetowne, Halifax, Moncton, Yarmouth, Fredericton, Saint John, Boston.
Air Ontario Limited/ Austin Airways (owned partly by AC) London, ON (Air Ont.) Timmins, ON (Austin)	Air Ontario: 4 Dash-8's, 9 Convair CV-580's, 3 Dash-8-100's, (7 Dash-8-100's), (3 Dash-8-300's). Austin Airways: 7 British Aerosapce HS-748, 3 DC-3's, 15 Cessna 402's, Twin Otters, 2 Cessna Citations, 4 Beech 99's, 1 Dash-8-100, (5 Dash-8-100's), (3 Dash-8-300's),5 DHC-6's.	Great Whale, Chisasibi/La Grande 2, Paint Hills/Wemindji, East Main, Rupert House, Montreal, Ottawa, Kingston, Trenton, Toronto, London, Windsor, Sarnia, North Bay, Sudbury, Elliot Lake, Sault Ste. Marie, Timmins, Cochrane, Hornepayne, Kapuskasing, Marathon, Manitouwadge, Thunder Bay, Geraldton, Sioux Lookout, Kenora/Minaki, Red Lake, Cat Lake, Pikangikum, Deer Lake, Sandy Lake, Round Lake, Pickle Lake, Fort Hope, Moosonee, Fort Albany, Kasechewan, Attawapiskat, Winisk/ Peawanuck, Fort Severn, Big Trout Lake, Kasabonika, Lansdowne, Fort Hope, Bearskin Lake, Sachigo, Muskrat Dam, Winnipeg, Hartford/Springfield, Cleveland, Minneapolis.
Northwest Territorial Airways Yellowknife, NWT	5 DC-3's	Frobisher Bay, Rankin Inlet, Winnipeg, Pelly Bay, Spence Bay, Gjoa Haven, Cambridge Bay, Coppermine, Holman Island, Yellowknife, Fort Simpson, Edmonton.
CANADIAN AIRLINES	4 HS-748-2A's	
Air Atlantic Canadian Partner	3 Dash-7's, 4 Dash-8-100's, (2 Dash-8-100's)	Gander, St. John's, Deer Lake, Stephenville, Saint-Pierre et Miquelon, Sydney, Halifax, Iles de la Madeleine, Moncton, Fredericton, Saint John, Yarmouth, Boston, Charlottetown.
Burrard Air Ltd. (has an agreement with CAI) Richmond, B.C.	1 Beaver, 3 Cessna 185's, 1 Cessna 206, 1 Piper Navajo Chieftan, 1 Piper Aztec, 3 Islanders, 2 Otters	

CANADIAN AIR CARRIERS		
Carrier & Head Office	**Fleet**	**Area of Operation**
Calm Air Intl. Ltd. Canadian Partner Thomspon, MB	1 Beechcraft Super King Air 200, 3 DHC-6 Twin Otters, 6 Navajo Chieftans, 4 HS-748, 1 DC-3	Coral Harbour, Repulse Bay, Baker Lake, Whale Cove, Chesterfield Inlet, Rankin Inlet, Lac Brochet, Tadoule Lake, Churchill, Brochet, York Landing, Kelsey, Ilford, St. Theresa, Island Lake, Oxford House, Shamattawa, Thompson, The Pas, Flin Flon, Winnipeg, Pukatawagan, Lynn Lake, Leaf Rapids, South Indian Lake, Eskimo Point, Pikwitonei.
NorcanAir/Time Air Canadian Partner Saskatoon, SA (Nor) Lethbridge, AB (Time)	NorcanAir: 2 Fairchild F-27J's, 2 Fokker F28-1000's, 1 Cessna Citation, 2 CV-640's, 1 Embraer EMB-110, 4 King Airs B-90, Time Air: 2 CV-640's, 4 Dash-7's, 3 CV-580's, 4 Dash-8-100's, 6 Dash-8-300's, 2 Shorts 360's	Rainbow Lake, High Level, Fort Chipewyan, Uranium City, Stoney Rapids, Peace River, Fort McMurray, Wollastan Lake, La Ronge, Prince Albert, Saskatoon, Minneapolis, Cold Lake, Lloydminster, Grande Prairie, Dawson Creek, Edmonton, Calgary, Regina, Medicine Hat, Lethbridge, Castlegar, Kelowna, Port Hardy, Vancouver, Kamloops, Penticton, Victoria, Comox, Campbell River, Powell River, Nanaimo.
Nordair Metro/Quebecair/ Pem-Air Ltd. Commercial Partner Montreal, PQ (Nordair) Montreal, (Quebecair) Pembroke, ON (Pem)	Quebecair: 8 CV-580's, 4 HS-748's, 2 F28-1000's Nordair Metro: 3 CV-580's Pem-Air: 6 Piper PA-31's, 1 PA-23	Nordair Metro: Val D'Or, Rouyn/Noranda, Bagotville, Quebec, Montreal, Mirabel, Ottawa. Quebecair: Blanc-Sablon, St Augustine, La Tabatiere, Tet-a-la-Baleine, Harrington Harbour/ Chevery, Gethsemani (La Romaine), Kegaska, Natashquan, Port-Menier, Baie-Johan-Beetz, Wabush/Labrador City, La Grand/Baie James, Havre St-Pierre, Sept-Iles, Gaspe, Baie Comeau/Hauterve, Bonaventure, Iles-de-la-Madeleine, Rimouski/Mont Joli, Rimouski, Chibougamau, Saguenay/Bagotville, Val D'Or, Rouyn/Noranda, Gatineau/Hull, Ottawa, Montreal, Quebec.
Ontario Express Canadian Partner		Thunder Bay, Sault Ste. Marie, Sudbury, Sarnia, Ottawa, Kingston, Toronto, London, Windsor.
INDEPENDANTS		
City Express Toronto, ON	3 Dash-7's, 4 Dash-8-100's	Toronto, Ottawa, London, Montreal, Peterborough, Hamilton, New York, Detroit.
Air Creebec Val D'Or, PQ	2 HS-748-2A's, 2 Cessna 402C's, 1 DHC-6-300, (1 Dash-8-100), 1 DC-3	Northwestern Quebec
Air-Dale Ltd. Sault Ste. Marie, ON	3 DC-3's, 2 Cessna 310's, 2 Piper Twin Comanches, 1 DHC-3 Otter, 4 DHC-2 Beavers, 4 DHC-6 Twin Otters, 2 Beech 18's, 2 Cessna 180's, 2 Dash-8-100	

CANADIAN AIR CARRIERS		
Carrier & Head Office	**Fleet**	**Area of Operation**
Air Inuit (1985) Ltd. Dorval, PQ	7 DHC-6-300's, 1 DHC-6-200, 1 HS-748, 1 Grumman Gulfstream G-159	
Air Maritime Gander, NF	3 HS-748's	
Air Muskoka		Gravenhurst, Toronto
Air Niagara Mississauga, ON	1 Cessna Citation 650, 3 Citation 500's, 2 Citation 550's, 1 Citation 501, 2 Piper Navajos 1 Fairchild Merlin IVA, 2 Merlin Metros	
Air Nootka Ltd. Tahsis, BC	4 DHC-2 Beavers, 1 Cessna Skywagon	
Air North Charter & Training Ltd. Whitehorse, YT	3 DC-3's, 1 DHC-4 Caribou, 1 Cessna U206, 1 PA-34 Seneca, 1 Beech 18, 2 PA-31 Navajos	
Air Providence Ltd. Fort Providence, NWT	2 PA-32R-300's, 1 Cessna 185	
Air Satellite Inc. Hauterive, PQ	1 Cessna 411A, 1 PA-30, 2 Cessna 310R's, 2 Cessna 404's	
Air Schefferville Schefferville, PQ	1 DHC-2, 3 DHC -3's, 1 DHC-6, 1 Cessna 180, 1 Cessna 337, 1 Beech Queenair	
Airspeed Aviation Inc. Abbotsford, BC		
Aklak Air Ltd. Inuvik, NWT	2 Cessna 3TOR's, 2 Cessna 185F's, 2 Navajo Chieftans, 3 DHC-300 Twin Otters, 1 Cessna 180, 2 Cessna 206's, 1 Beech King Air A100	
Aklavik Flying Service Inuvik, NWT	1 DHC-6 Otter, 1 Cessna 337G, 1 Beech Baron	
Aquila Air Ltd. Qualicum, BC	2 PA-23-150's, 1 PA-23-250	Vancouver, Nanaimo, Qualicum Beach, Victoria , Powell River, Gibbons Sechlet, Texado Island
Atlantair (1981) Ltd. Rothesay, NB	1 PA-34-200T, 1 PA-31-310	
Atlantic Airways Ltd. St. Johns's, NF	1 King Air 200, 2 Navajo Chieftans, 1 Aztec, 6 Piper Cherokees	

CANADIAN AIR CARRIERS		
Carrier & Head Office	**Fleet**	**Area of Operation**
Bearskin Lake Air Service Sioux Lookout, ON	1 DC-3, 2 DHC-3 Twin Otters, 2 Otters, 2 Beech 99's, 6 Navajos, 6 Aztecs, 4 Cessna 185's	
Bordaire Ltd. Fort Frances, ON	1 Baron, 1 Navajo	
Kenn Borek Air Ltd. Calgary, AB	12 DHC-6 Twin Otters, 2 Beech 99's, 1 Beech C-90, 1 Beech 100, 1 DHC-4A Caribou	
Buffalo Airways Ltd. Fort Smith, NWT	3 DC-3's, 1 Cessna 402, 1 Baron 58, 1 Islander 2A, 1 Beech 18.	
Chilcotin-Caribou Aviation Ltd. Williams Lake, BC	1 Cessna UT206, 1 Rockwell Aero Commander	
Chilliwack Aviation Ltd. Chilliwack, BC	1 Cessna 206 (Amphibian), 1 PA-32-250C Aztec, 3 Cessna 182's, 1 Cessna 206, 1 Cessna 207,	
Commuter Express		Toronto, Columbus, Dayton, Grand Rapids, Saginaw, Allentown, Harrisbury.
Coval Air Ltd. Campbell River, BC		
Ellair Ltd. Thompson, MB	1 DHC-6 Beaver, 1 Beech 18, 1 Navajo, 1 Seneca II, 1 Chieftan	
First Air Carp, ON (has an agreement with Air Canada)	4 HS-748-2A's, 4 DC-3's, 8 DHC-6 300's, 1 Citation 500	Ottawa, Boston, Frobisher Bay, Nuuk, Lake Harbour, Broughton Island, Clyde River, Pond Inlet, Nanisivik, Igloolik, Hall Beach, Cape Dorset, Coral Harbour, Pelly Bay, Spence Bay, Gjoa Haven, Cambridge Bay, Yellowknife, Pangnirtung.
Gander Aviation Ltd. Gander, NF	1 DHC-3 Otter, 1 DHC-2 Turbo Beaver, 2 DHC-2 Beavers, 1 180J Skywagon	
Georgian Bay Airways Parry Sound, ON	8 PA-23-250's, 2 Cessna 185's, 1 DHC-2 Beaver	
Hearst Air Service Ltd. Hearst, ON	1 DHC Beaver, 1 Navajo Chieftan	
Hyack Air (1981) Ltd. New Westminster, BC	1 Cessna 185, 3 Cessna 206's, 2 DHC-2 Beavers	
Intercity Airways Oshawa, ON	3 HS-748's	

CANADIAN AIR CARRIERS		
Carrier & Head Office	**Fleet**	**Area of Operation**
Jackson Air Services Ltd. Flin Flon, MB	3 Cessna 185's, 2 DHC-2 Beavers, 1 Cessna 310IIR, 1 DHC-3 Otter	
Keewatin Air Ltd. Winnipeg, MB	2 DHC-2 Beavers, 1 IAI Westwind III, 1 Beech Turbo Tradewind, 1 Queenair A65 Excalibur 800, 1 Merlin IIA	
Kelowna Flightcraft Air Charter Ltd. Kelowna, BC	5 CV-580's, 1 Beech A-60 Duke, 1 Gulfstream G-159, 1 Beech B-80, 1 Cessna 310M, 1 Cessna 210M	
Labrador Airways Ltd. Goose Bay, NF	1 DHC-3 Otter, 2 DHC-6 Twin Otters, 1 QueenAir B8800, 1 Aero Commander, 1 Saunders ST-27, 1 DC-3	
Mall Airways		Toronto, Montreal, Syracuse, Albany, Hartford, New York/Newark, Rochester, White Plains.
McCully Aviation (1985) Nanaimo, BC	2 Cessna 185's (floats), 2 DHC-2 Beavers (floats)	
Montmagny Air Service Montmagny, PQ	1 Pilatus 2A-27, 1 Cessna U206G	
Mountain Pacific Air Ltd. Richmond, BC	2 Bandeirantes	
Nahanni Air Services Ltd. Norman Wells, NWT	1 Helio Courier, 1 DC-3, 2 Islanders, 1 Pilatus Turbo Porter, 2 DHC-6 Twin Otters	
Nordair Ville Mont Royal, PQ	5 FH-227's	
Norontair Airlines North Bay, ON	6 DHC-6 Twin Otters, 1 Piper Navajo, 2 Dash-8's	Red Lake, Kenora, Dryden , Fort Frances, Atikokan, Thunder bay, Terrace Bay, Geraldton, Pickle Lake, Hornepayne, Hearst, Kapuskasing, Timmins, Wawa, Sault Ste. Marie, Chapleau, Elliot Lake, Sudbury, Kirkland Lake, North Bay.
North Coast Air Services Prince Rupert, BC	2 Cessna 180's, 4 DHC-2 Beavers, 1 G-73 Mallard	
Northern Thunderbird Air Prince George, BC	2 Cessna 185's, 1 Cessna 337, 1 DHC-2 Beaver, 2 Beech 18's, 1 DHC-6 Twin Otter, 1 PA-23, 1 Cessna 210	
Northland Air Manitoba Winnipeg, MB	4 DC-3's, 1 Cessna 402C, 2 HS-748's, 5 Curtiss C-46's, 1 Dash-8-100	

CANADIAN AIR CARRIERS		
Carrier & Head Office	**Fleet**	**Area of Operation**
Northway Aviation Ltd. Ames, MB	2 Cessna 180's, 1 Cessna 185, 1 Noorduyn Norseman, 1 DHC-2 Beaver, 1 Cessna 206, 3 Islanders, 1 DHC-3 Otter	
Pacific Rim Airlines Port Alberni, BC	2 Cessna 185's (floats), 2 DHC-2 Beavers (floats), 1 PA-23-250 Aztec	
Peace Air Ltd. Peace River, AB	5 Navajos, 1 Islander, 3 Aztecs, 9 Cessna 185's, 5 Cessna 206's	
Perimeter Airlines (Inland) Winnipeg, MB	3 DC-3's, 4 Queenairs	
Powell Air Ltd. Powell River, BC	3 DHC-2 Beavers, 2 Cessna 180 (floats), 2 Piper PA-31 Navajos, 1 Aero Commander, 2 DHC-3 Otters, 1 Corvair 440	
Ptarmigan Airways Ltd. Yellowknife, NWT	1 Chieftan, 1 Cheyenne III, 1 Aztec, 1 Piper T1040, 4 DHC-6 Twin Otters, 2 DHC-2 MK Turbo Beavers, 1 Cessna 185	
Quebec Aviation Ltd. Quebec City, PQ	2 Beech 99's, 5 PA-31 Navajos, 2 Cessna 310's 2 Cessna 340's, 1 Lear 35A, 1 Commander 840	
Raecom Air Ltd. Yellowknife, NWT	2 DHC-3 Otters, 2 Cessna 185's, 1 Cessna 206	
Ram Air Charter Ltd. Inuvik, NWT	1 Seneca PA-34, 1 2A-27 Islander, 2 Cessna 207's, 2 Cessna 185's, 1 Cessna 177B	
Skycraft Air Transport Inc. Oshawa, ON	3 DC-3's, 1 Beech E18S, 1 Aztec, 1 Cessna 402C, 1 Citation, 1 Piper Warrior, 1 Beech Duchess, 1 Cessna Titan 404, 2 EMB-110's, 1 Shorts 330	
Skylink Airlines Delta, BC	2 EMB-100P1's, 1 PA-31-310, 1 31-350, 1 PA-34-200	
Soundair Corp. Mississauga, ON	13 Metro II/Merlin IV's, 2 DC-3's, 3 Cessna 402's, 3 Cessna 310's, 1 Lear 35A, 1 Falcon 20E	
South West Air Ltd. Windsor, ON	2 PA-31-350 Chieftans, 2 PA-31-310 Navajos, 1 PA-34 Seneca	
Trans North Turbo Air Ltd Whitehorse, YT	1 Cessna 310, 2 Cessna 404's, 2 DC-3's, 2 EMB-110's	
Trans Provincial Airlines Prince Rupert, BC	5 Grumman Goose G21A's, 2 Goose G21C's, 3 DHC-3 Otters, 10 DHC-2 Beavers, 1 Cessna 180, 1 Islander, 1 DC-3	

CANADIAN AIR CARRIERS		
Carrier & Head Office	**Fleet**	**Area of Operation**
Tyee Airways Ltd. Sechelt, BC	2 Cessna 185's (floats), 4 DHC-2 Beavers (floats), 1 Cessna 180	
Voyageur Airways Ltd. Hornell Heights, ON	4 Cheyennes, 1 Navajo, 1 Cessna Cutlass, 1 DC-3, 3 ST-27's, 1 KingAir 90, 2 KingAir 100's	
Wapiti Aviation Ltd. Grande Prairie, AB	1 Cessna Hawk XP, 1 Cessna 206, 2 PA-44's, 1 PA-23-250, 1 PA-31-350, 1 EMB-110, 1 Cessna 182RG, 1 Cheyenne	
Wilderness Airline (1975) Ltd. Bella Coola, BC	3 Cessna 185's, 1 DHC-2 Beaver, 1 Islander, 2 PA-31-350 Aztecs, 1 Cessna Centurion, 1 Cessna Turbo Stationair	
References: 9 - 18, 28.		

APPENDIX C:

Selected Aircraft - Illustrations and Dimensional Data

402 BUSINESSLINER
AND
402 UTILILINER

MODEL 402C

AIRFOILS

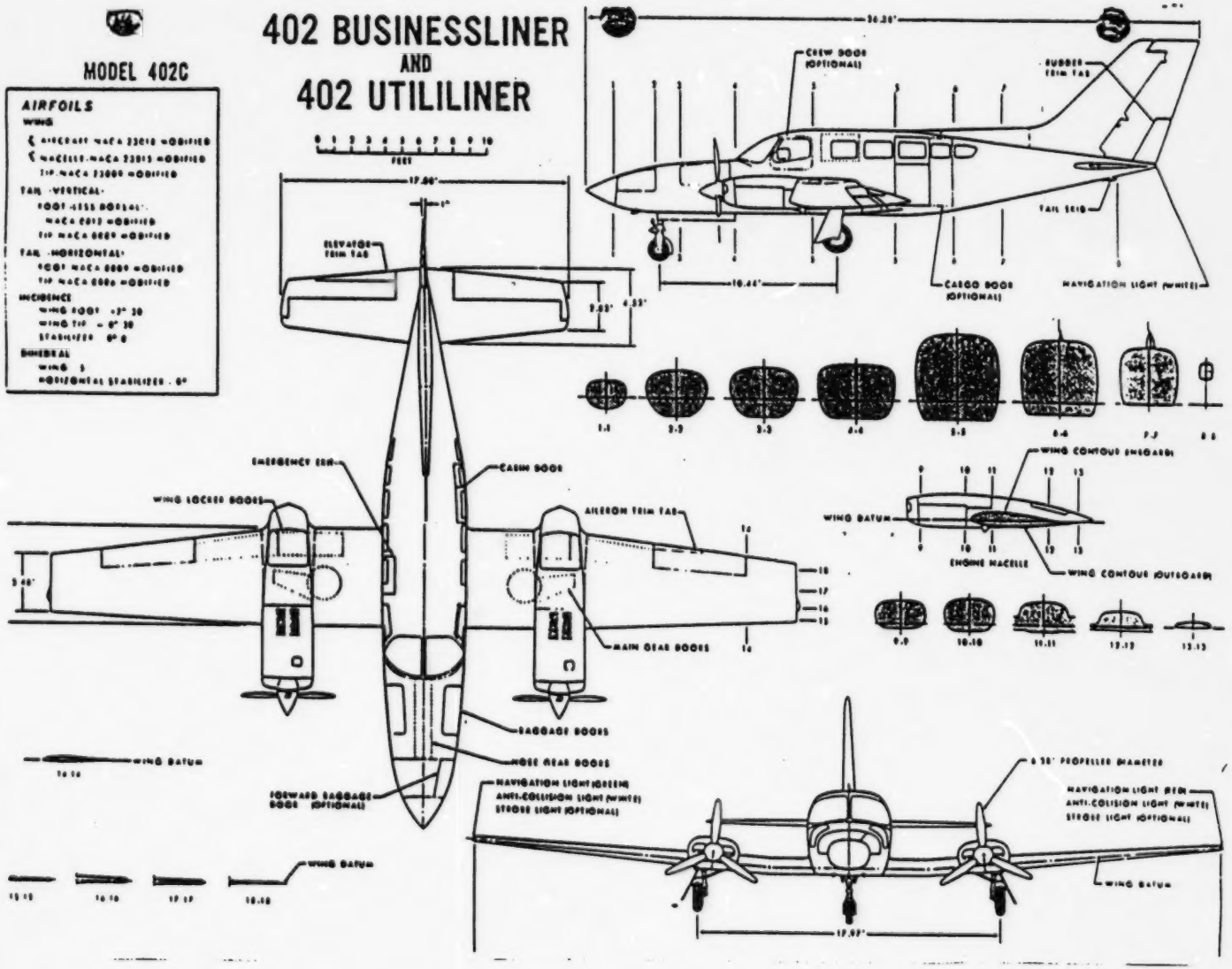
WING

TAIL - VERTICAL

TAIL - HORIZONTAL

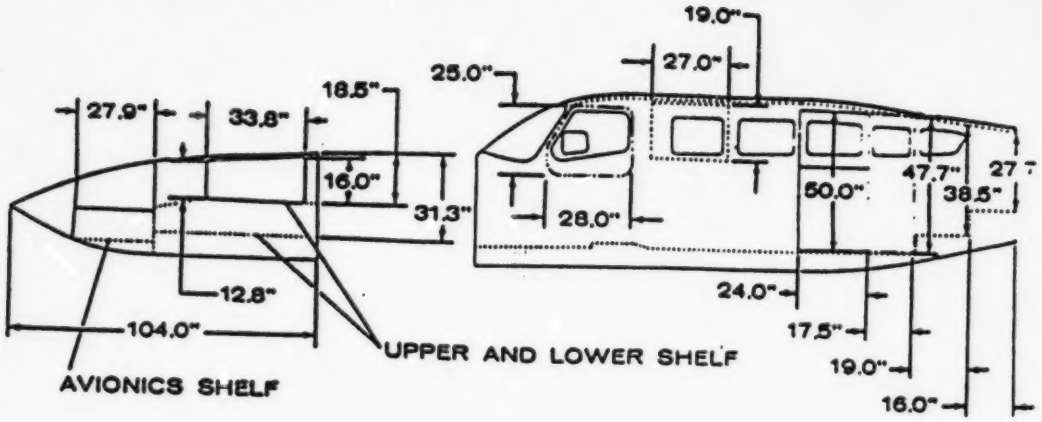
INCIDENCE

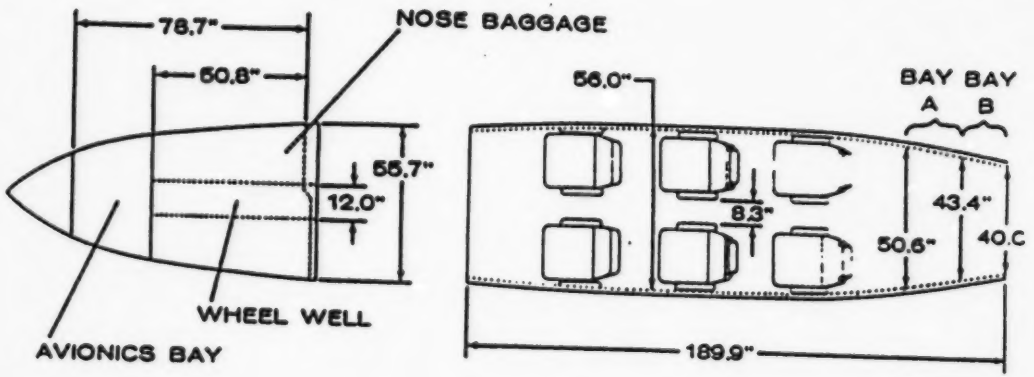
DIHEDRAL



Cessna 402C

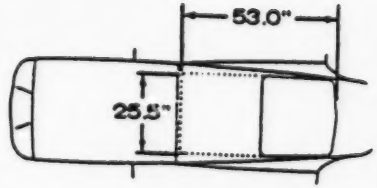
3-View Diagram

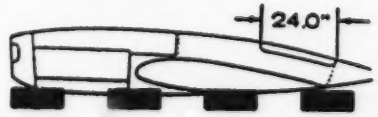




BUSINESSLINER BAGGAGE
COMPARTMENT VOLUME — CUBIC FEET

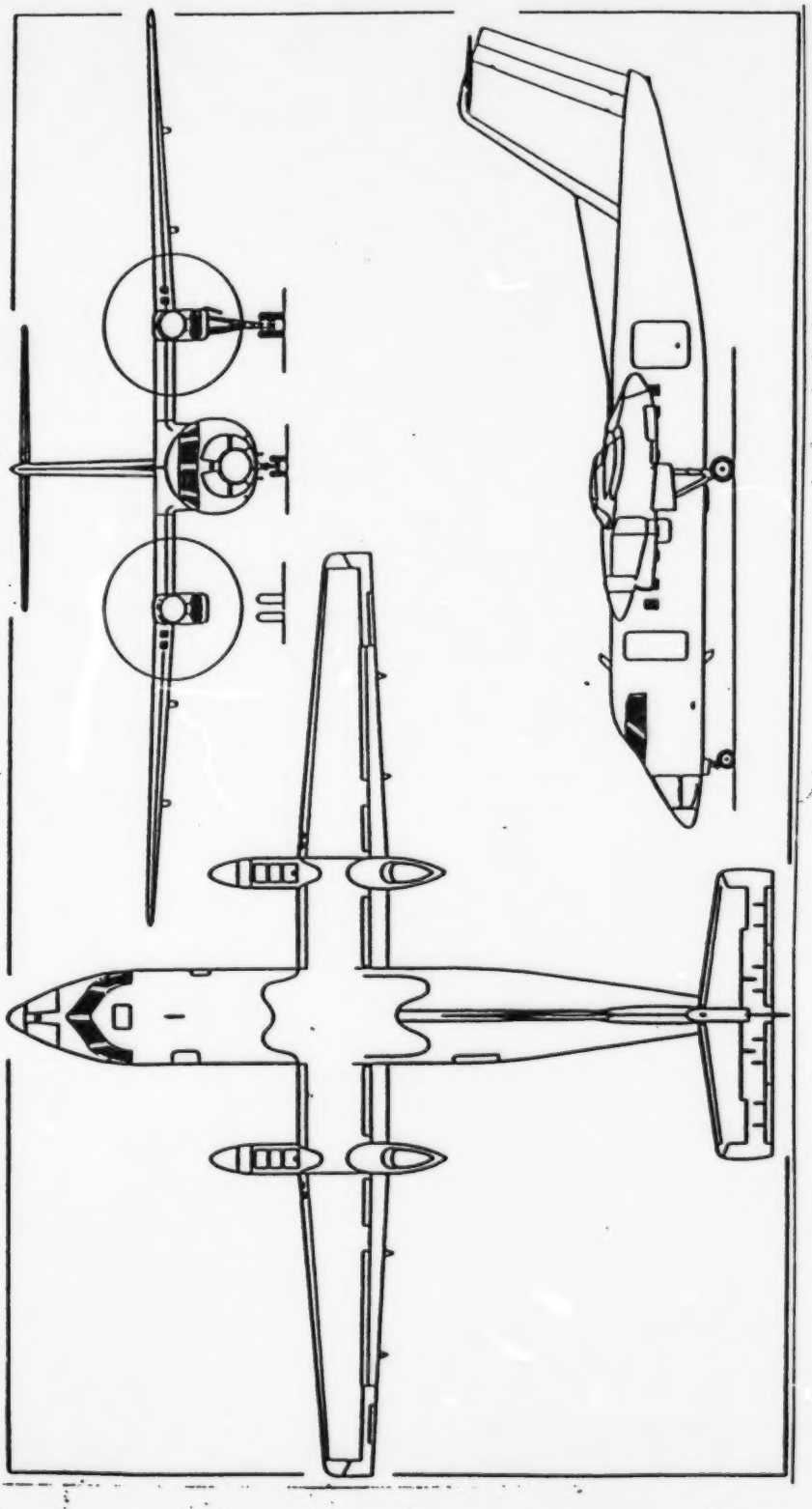
AVIONICS BAY	11.0
NOSE	26.0
WING LOCKER EACH (STD)	8.9
AFT CABIN (BAY A AND BAY B)	31.7

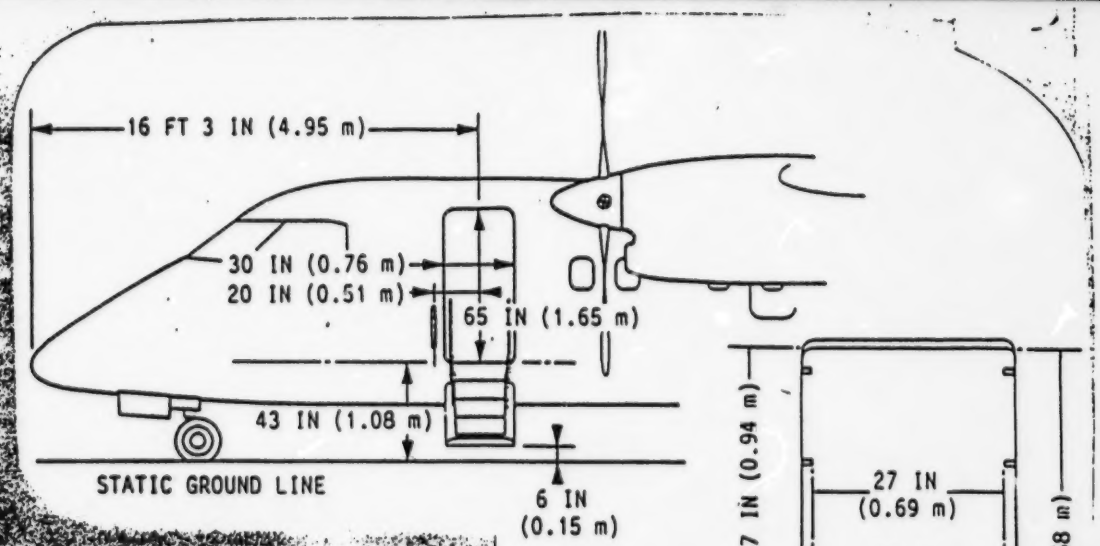


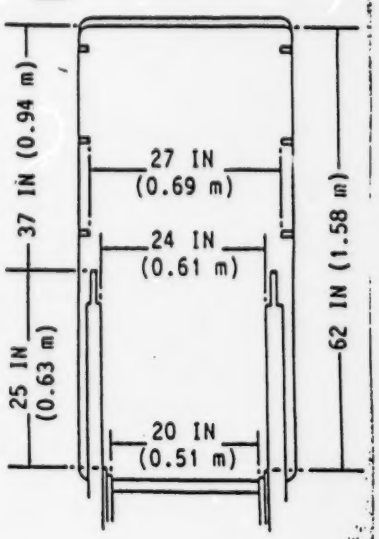


DeHavilland Dash-8

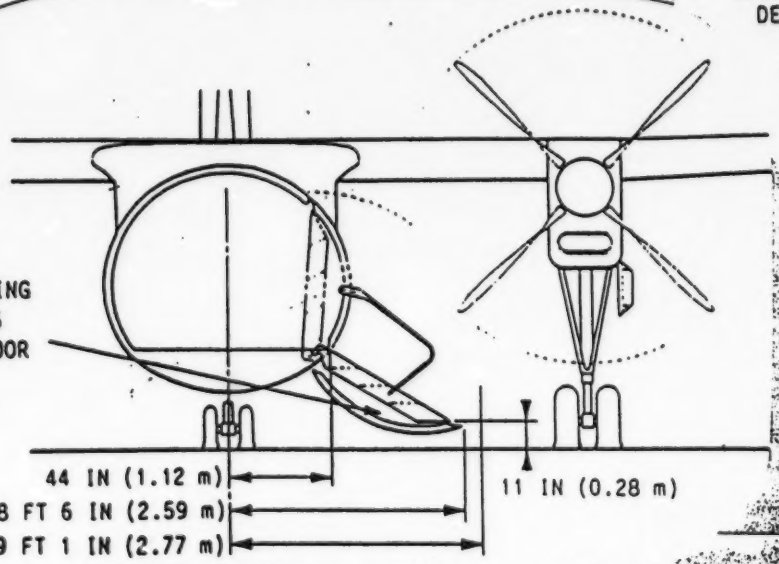
3-View Diagram

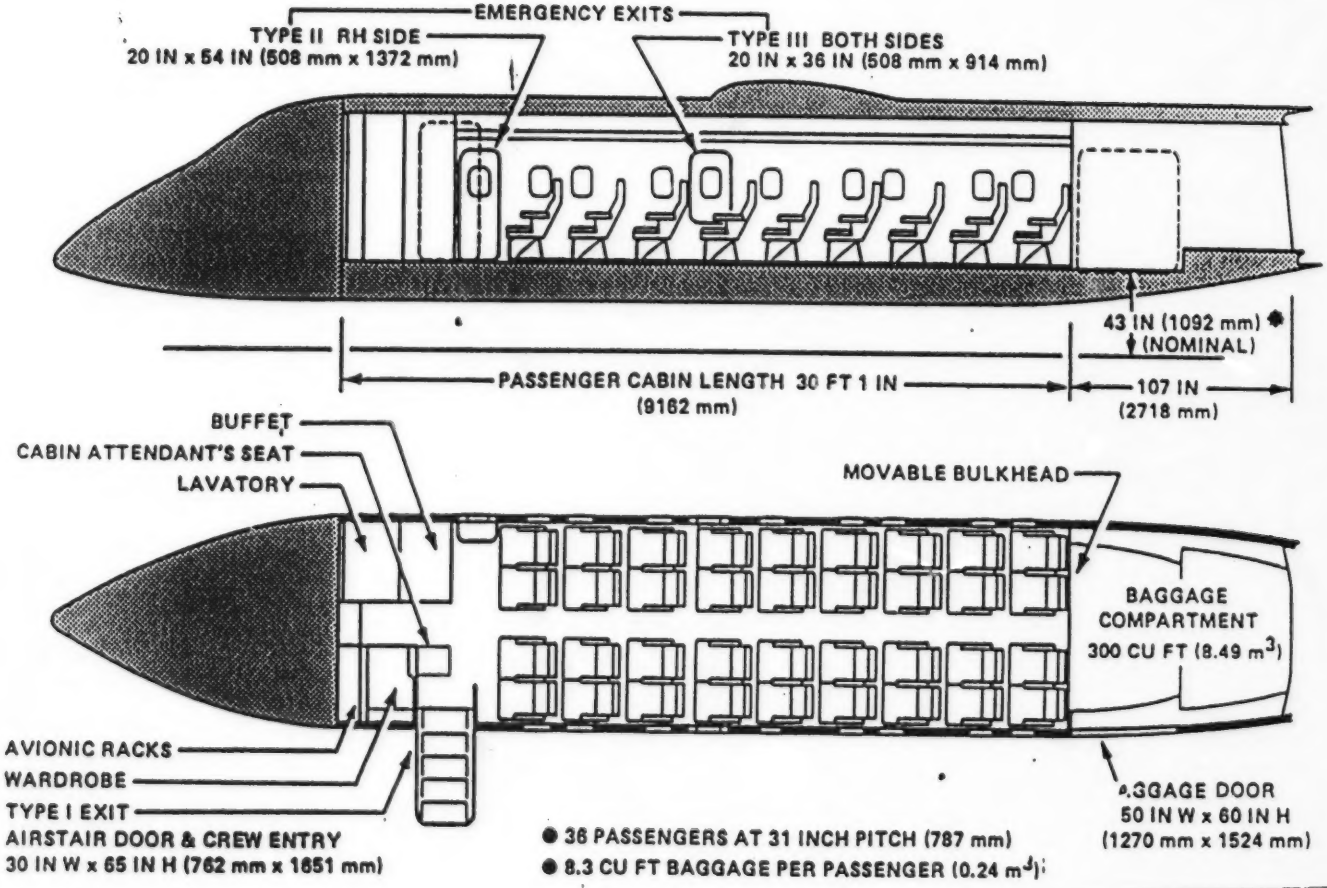


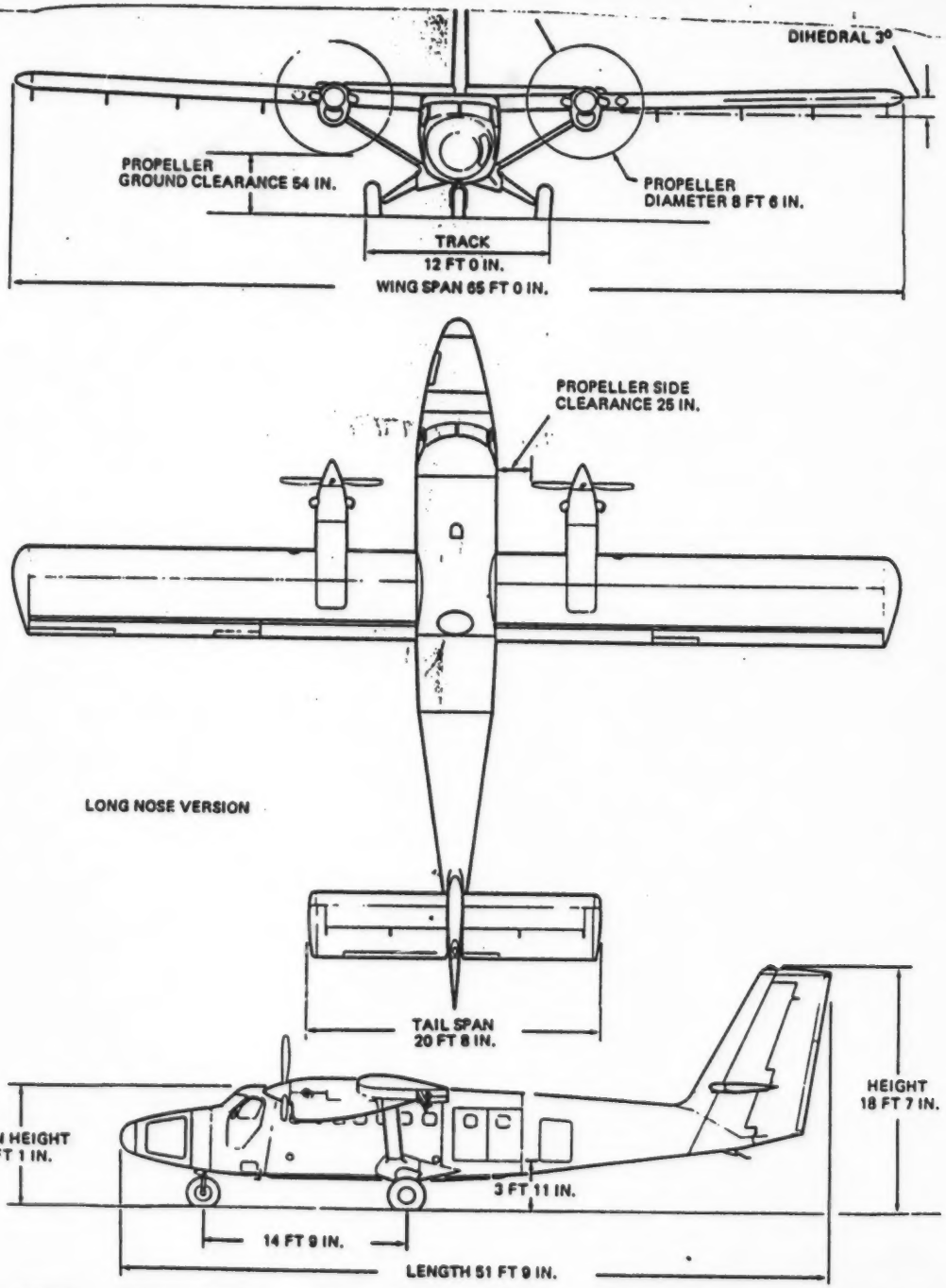




AIRSTAIR DOOR
CLEARANCE
DETAILS




EMERGENCY EXITS
TYPE II RH SIDE
20 IN x 54 IN (508 mm x 1372 mm)
TYPE III BOTH SIDES
20 IN x 36 IN (508 mm x 914 mm)
43 IN (1092 mm)
(NOMINAL)
PASSENGER CABIN LENGTH 30 FT 1 IN
(9162 mm)
107 IN
(2718 mm)
BUFFET
CABIN ATTENDANT'S SEAT
LAVATORY
MOVABLE BULKHEAD
BAGGAGE
COMPARTMENT
300 CU FT (8.49 m3)
AVIONIC RACKS
WARDROBE
TYPE I EXIT
AIRSTAIR DOOR & CREW ENTRY
30 IN W x 65 IN H (762 mm x 1651 mm)
BAGGAGE DOOR
50 IN W x 60 IN H
(1270 mm x 1524 mm)
● 36 PASSENGERS AT 31 INCH PITCH (787 mm)
● 8.3 CU FT BAGGAGE PER PASSENGER (0.24 m3)

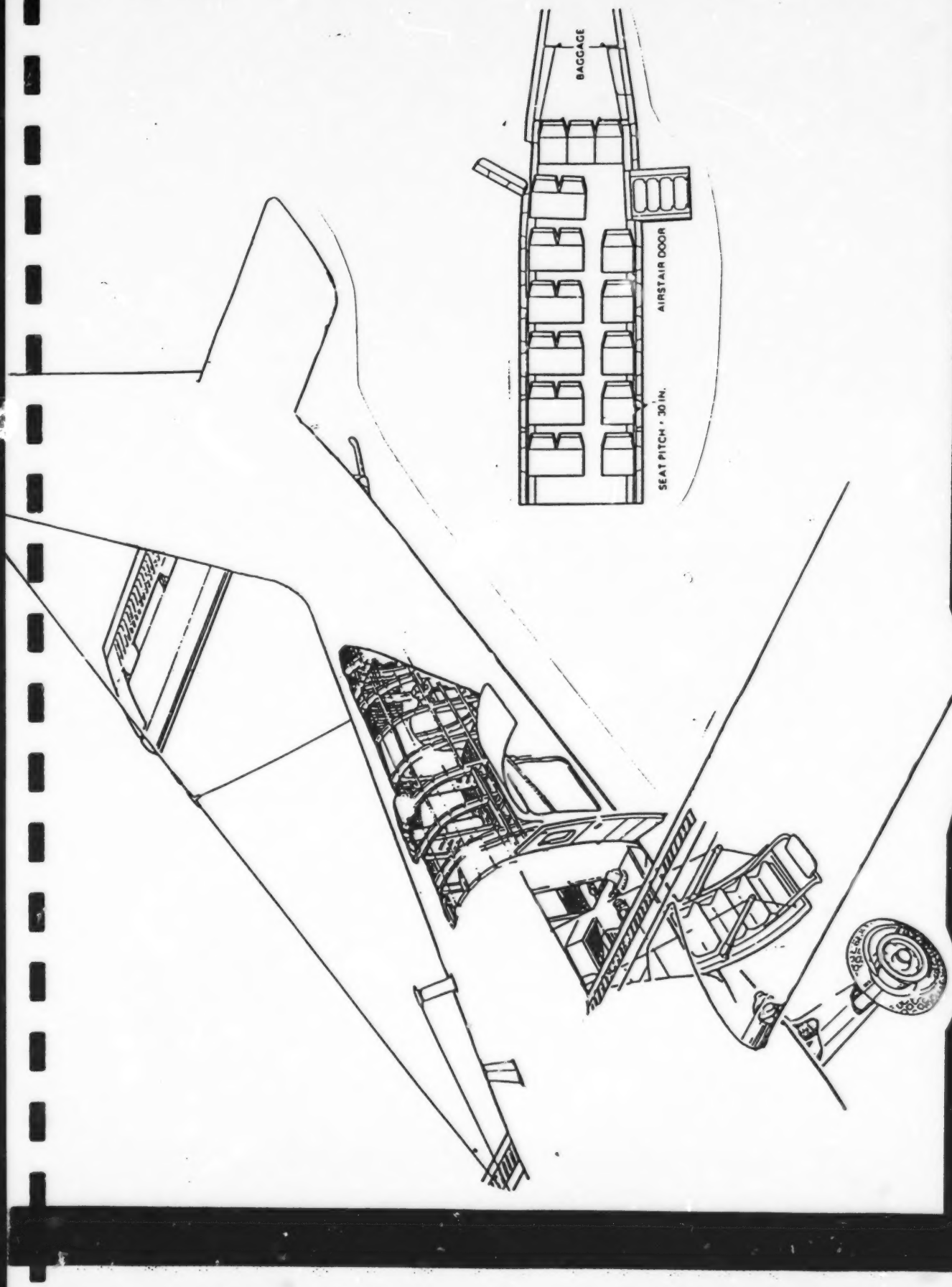


DeHavilland Twin Otter

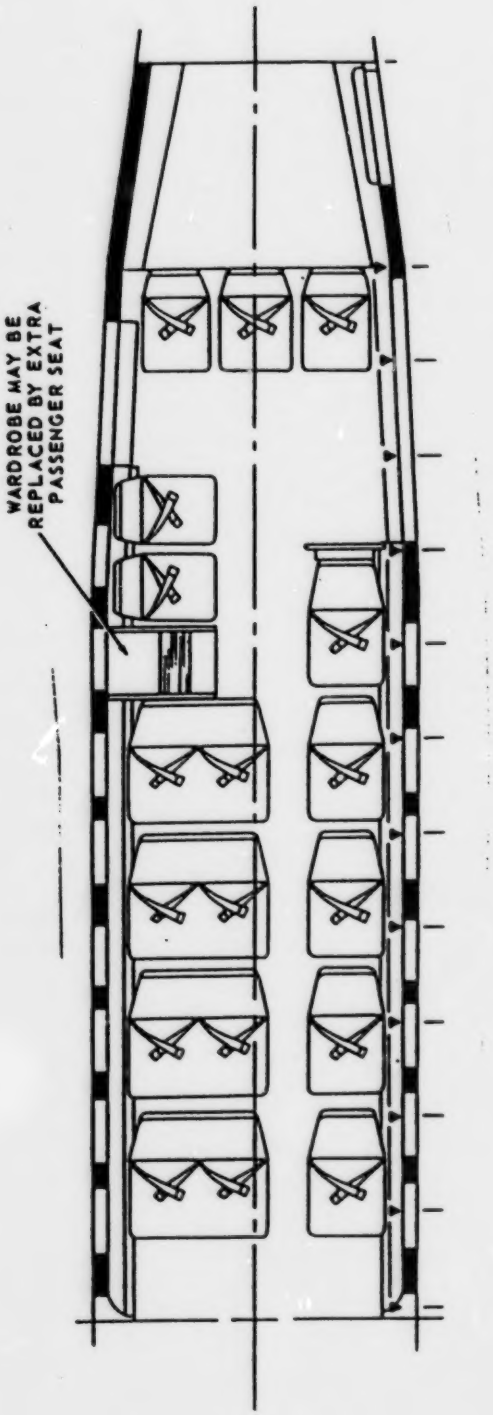
3-View Diagram

DeHavilland Twin Otter

Stairway

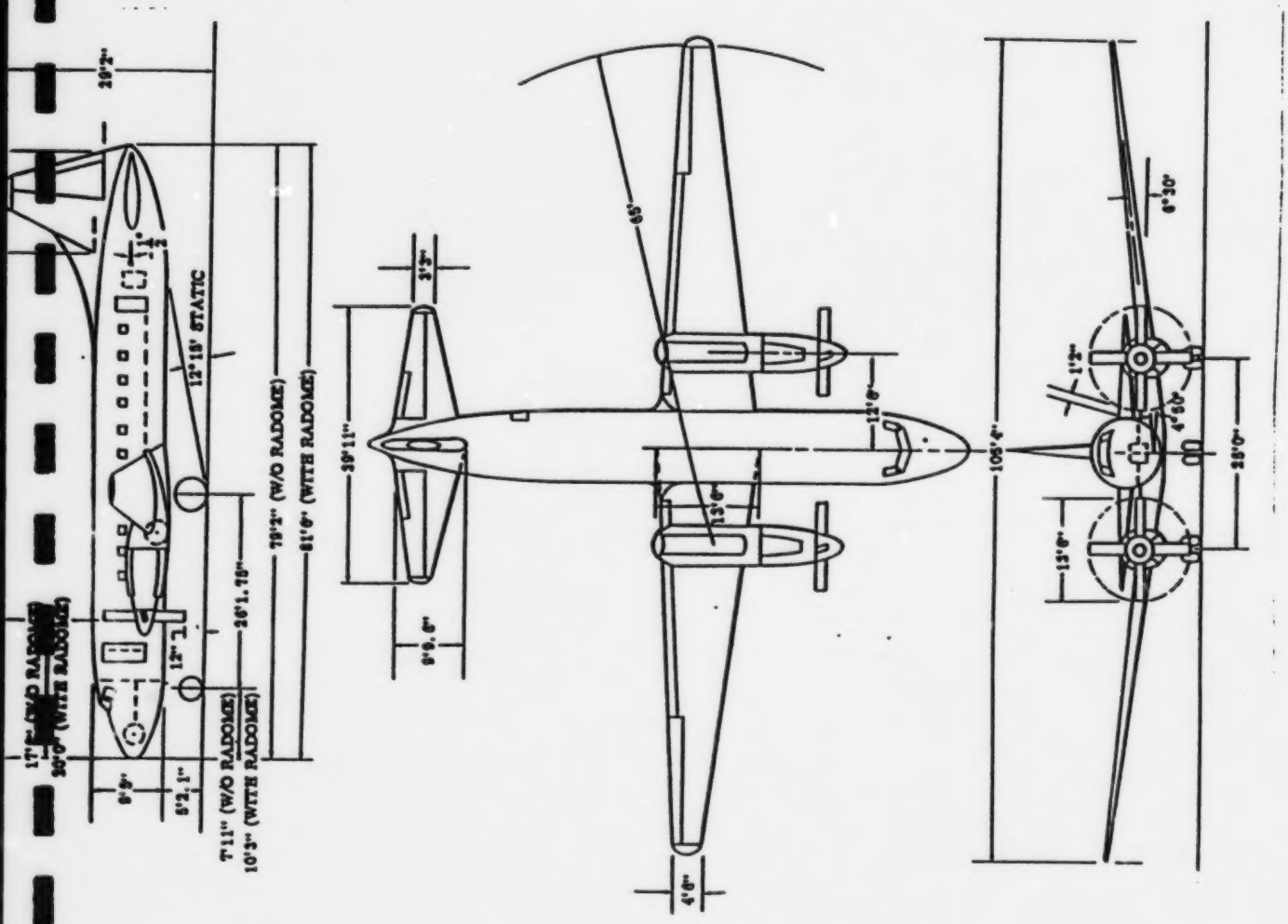


Vestibule and Aisleway Configuration

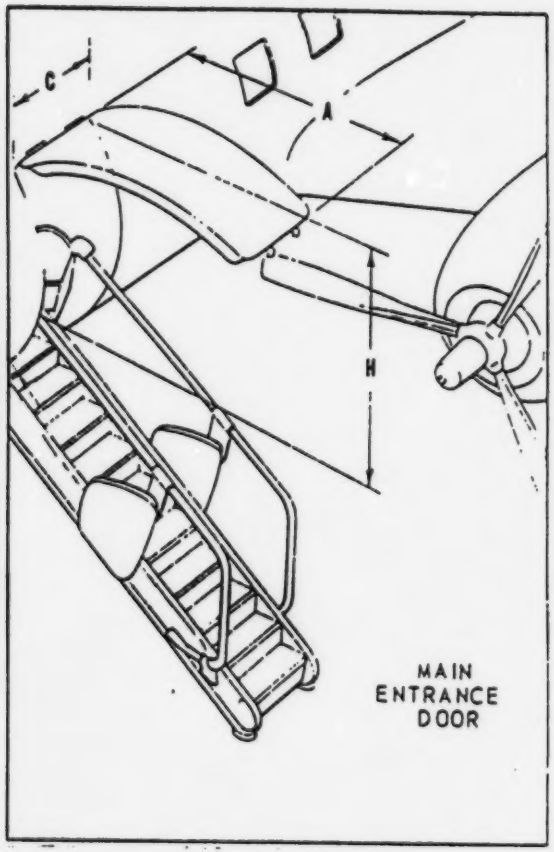


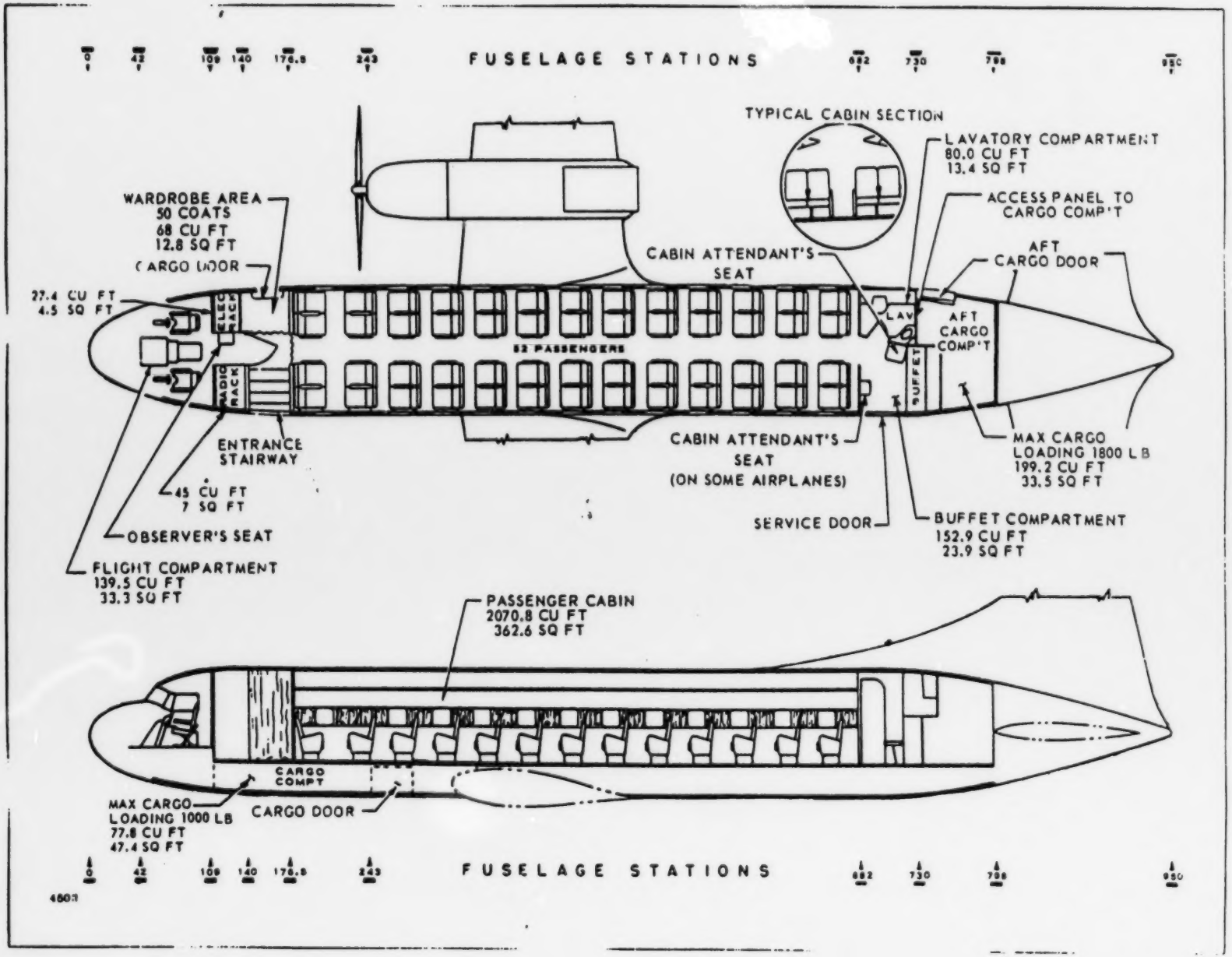
. Convair 580

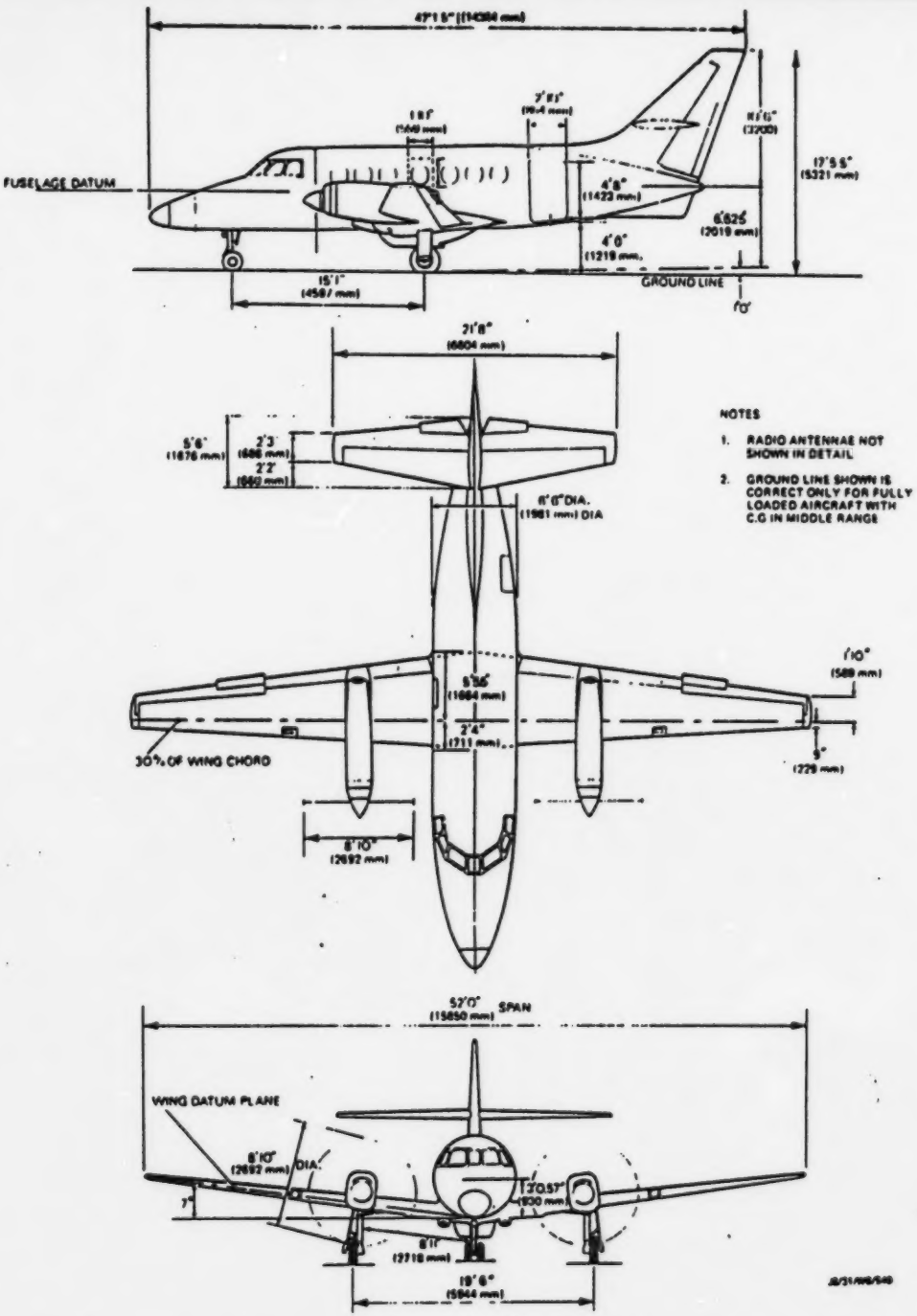
3-View Diagram

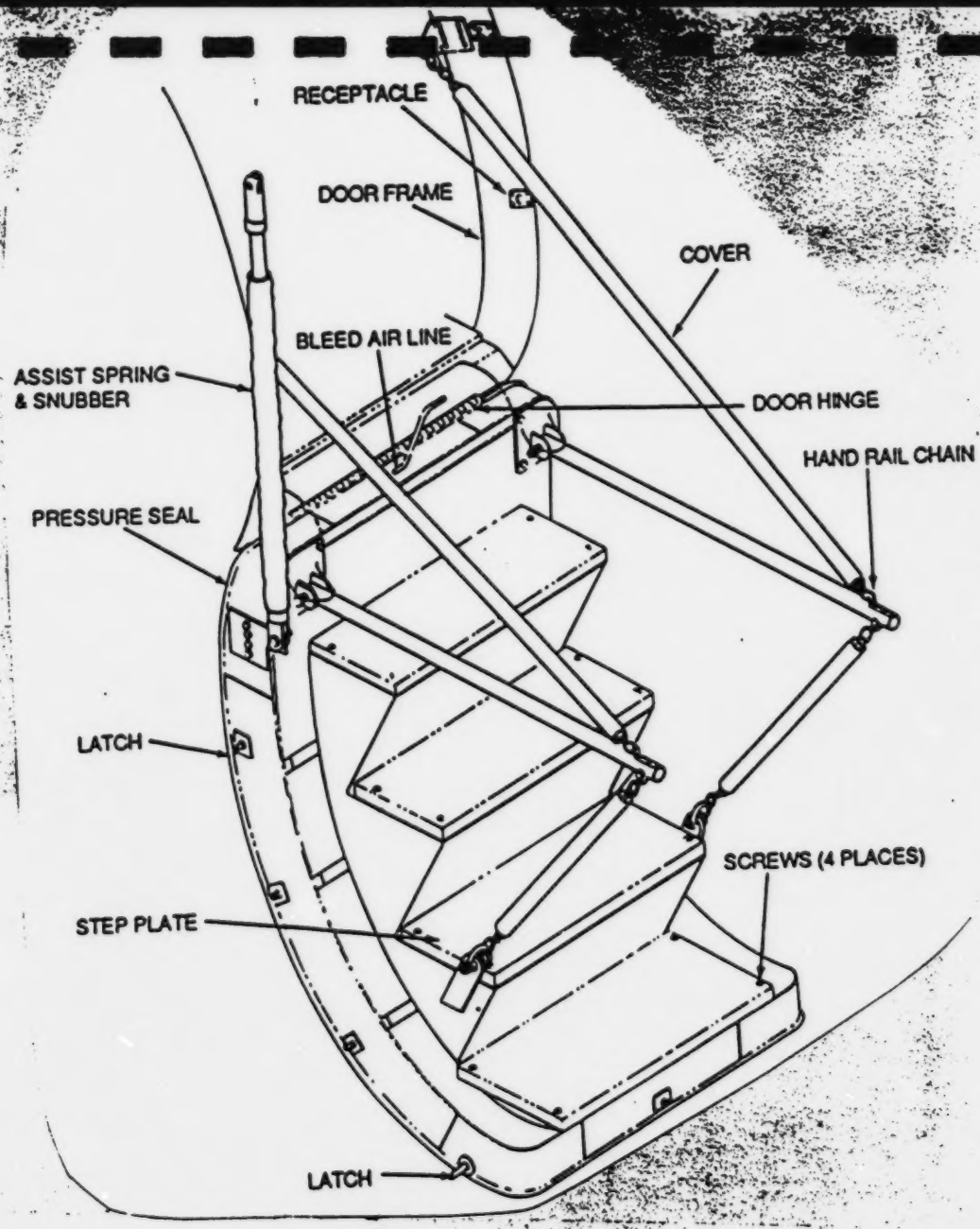


		REAR CARGO DOOR	FORWARD CARGO DOOR	MAIN ENTRANCE DOOR
A	LENGTH	4' 7.5"	4' 7.5"	7' 3 "
B	CLEARANCE - HINGE TO FLOOR LINE	4' 2 "	4' 2 "	
C	WIDTH OF FRAME	2' 6 "	3' 0.5"	3' 0.5"
D	BOTTOM OF DOOR TO GROUND	8' 1.9"	7' 3. "	
E	AFT EDGE OF DOOR TO STABILIZER	3' 1.5"		
F	AFT EDGE OF DOOR TO PROPELLER		4' 8 "	
G	DOOR ARC TO FUSELAGE AT FLOOR LINE	2' 1.5"	2' 1 "	
H	CLEARANCE - HINGE TO STEP			6' 4.8"

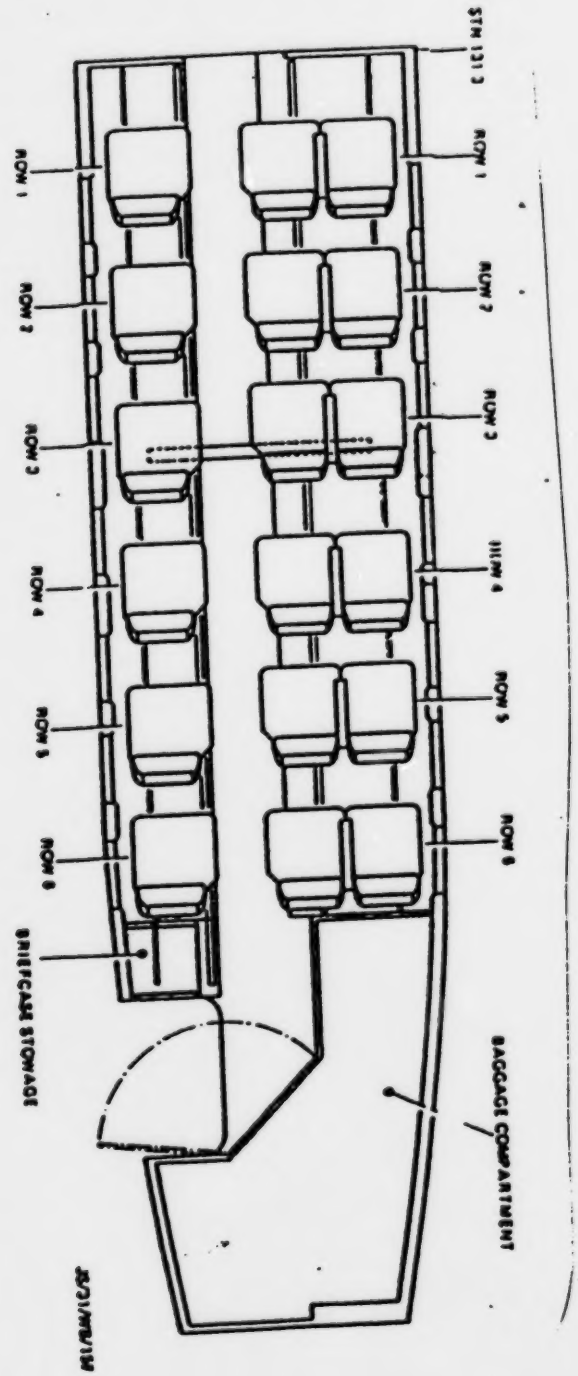



0
42
109
140
176.8
243
FUSELAGE STATIONS
682
730
798
950
TYPICAL CABIN SECTION
LAVATORY COMPARTMENT
80.0 CU FT
13.4 SQ FT
ACCESS PANEL TO
CARGO COMP'T
WARDROBE AREA
50 COATS
68 CU FT
12.8 SQ FT
CARGO DOOR
CABIN ATTENDANT'S
SEAT
AFT
CARGO DOOR
27.4 CU FT
4.5 SQ FT
ELEC RACK
52 PASSENGERS
LAV
AFT
CARGO
COMP'T
RADIO RACK
BUFFET
ENTRANCE
STAIRWAY
CABIN ATTENDANT'S
SEAT
(ON SOME AIRPLANES)
MAX CARGO
LOADING 1800 LB
199.2 CU FT
33.5 SQ FT
45 CU FT
7 SQ FT
OBSERVER'S SEAT
SERVICE DOOR
BUFFET COMPARTMENT
152.9 CU FT
23.9 SQ FT
FLIGHT COMPARTMENT
139.5 CU FT
33.3 SQ FT
PASSENGER CABIN
2070.8 CU FT
362.6 SQ FT
CARGO
COMPT
MAX CARGO
LOADING 1000 LB
77.8 CU FT
47.4 SQ FT
CARGO DOOR
0
42
109
140
176.8
243
FUSELAGE STATIONS
682
730
798
950
4503

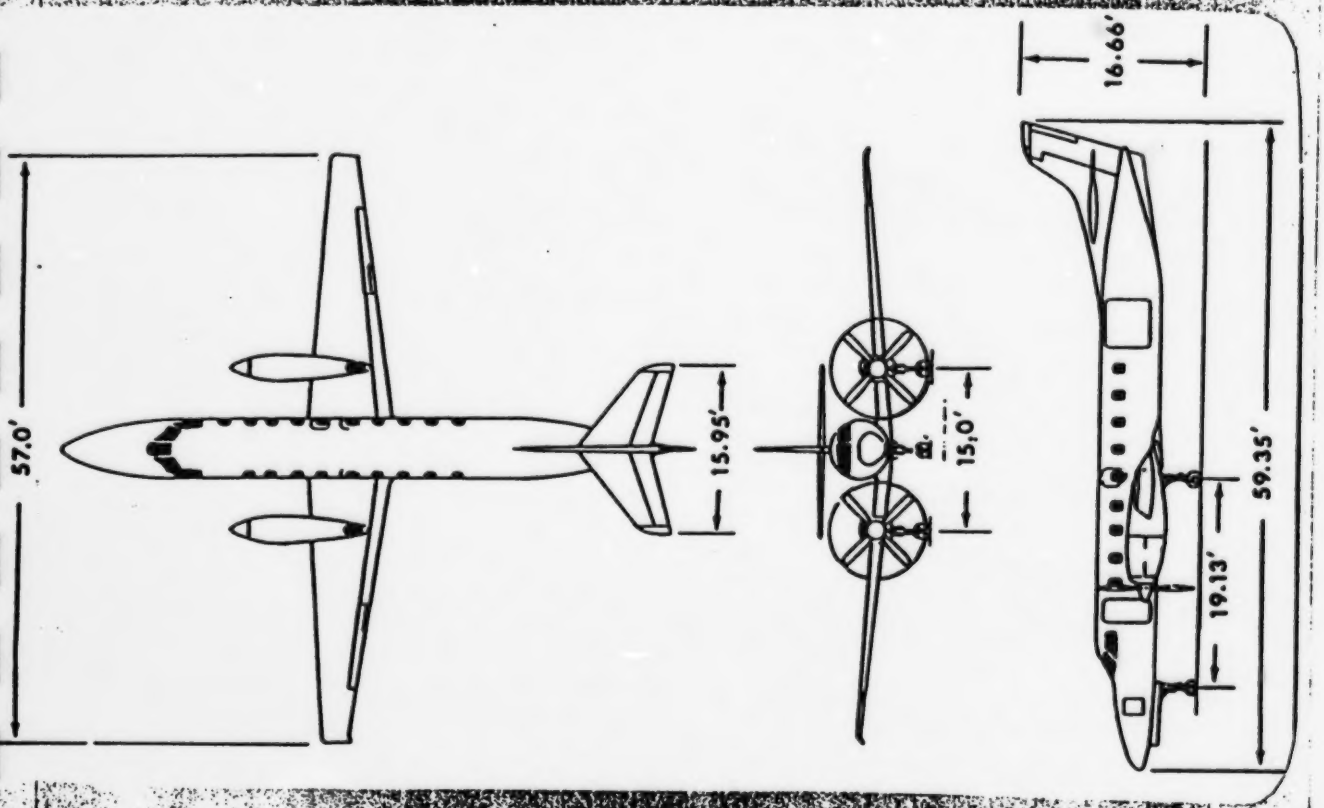

FUSELAGE DATUM
GROUND LINE
0°
15'1"
(4587 mm)
4'8"
(1423 mm)
6'6.5"
(2019 mm)
4'0"
(1219 mm)
11'6"
(3200)
17'5.5"
(5321 mm)
21'8"
(6604 mm)
5'6"
(1676 mm)
2'3"
(686 mm)
2'2"
(660 mm)
6'6"DIA.
(1981 mm) DIA
NOTES
1. RADIO ANTENNAE NOT SHOWN IN DETAIL
2. GROUND LINE SHOWN IS CORRECT ONLY FOR FULLY LOADED AIRCRAFT WITH C.G IN MIDDLE RANGE
1°10"
(589 mm)
5'36"
(1664 mm)
2'4"
(711 mm)
9"
(229 mm)
30% OF WING CHORD
8'10"
(2692 mm)
52'0" SPAN
(15850 mm)
WING DATUM PLANE
8'10"
(2692 mm) DIA.
7°
3'0.57"
(930 mm)
8'11"
(2718 mm)
19'6"
(5944 mm)

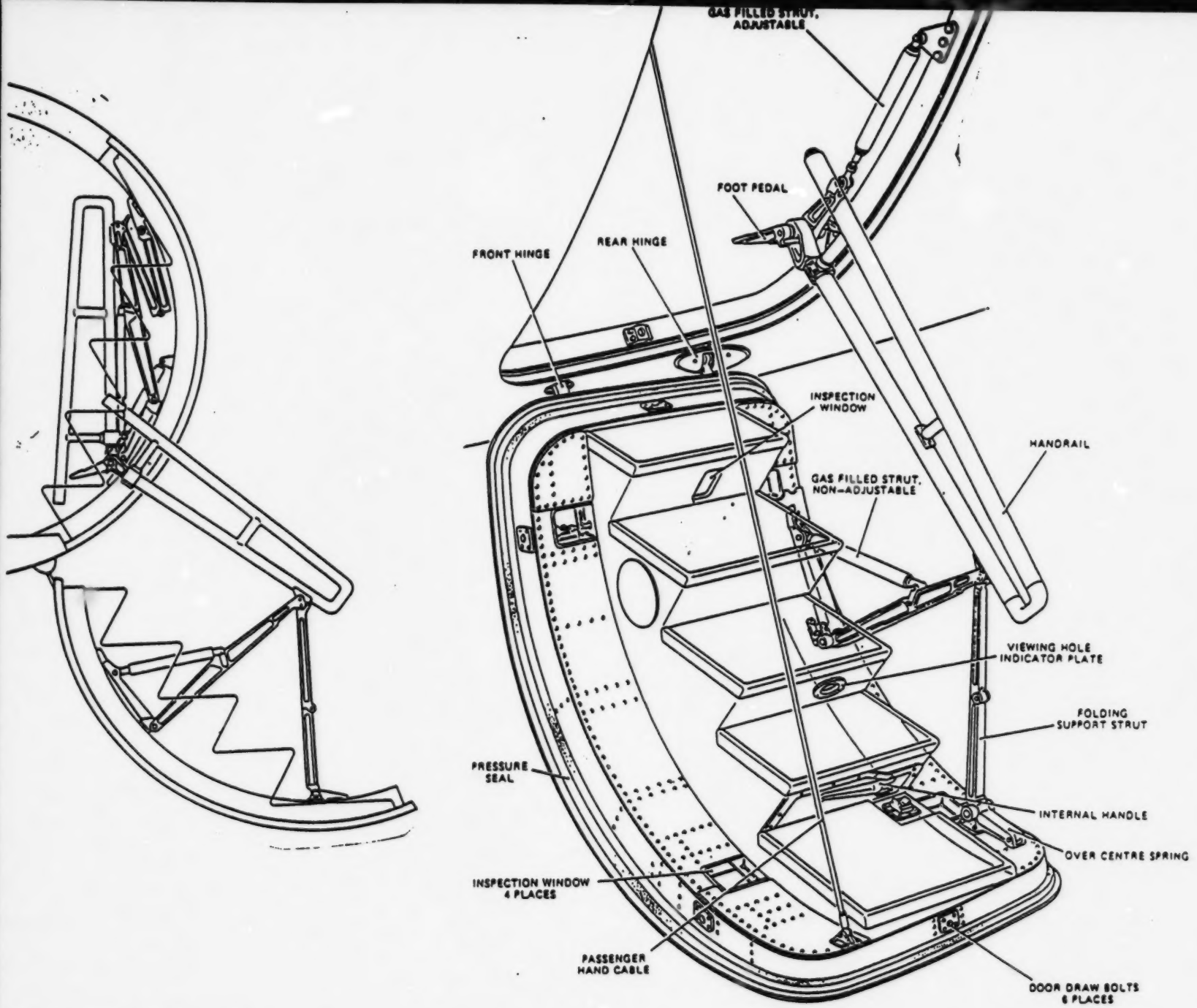

RECEPTACLE
DOOR FRAME
COVER
BLEED AIR LINE
ASSIST SPRING & SNUBBER
DOOR HINGE
HAND RAIL CHAIN
PRESSURE SEAL
LATCH
SCREWS (4 PLACES)
STEP PLATE
LATCH

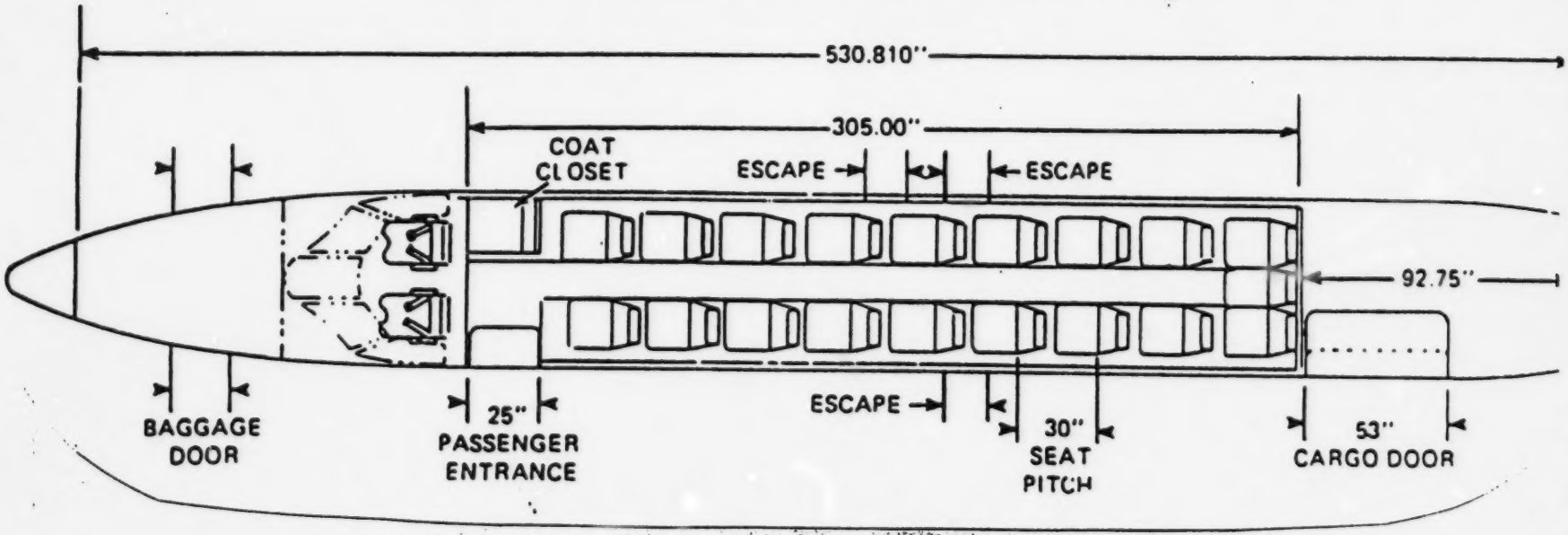
Vestibule and Aisleway Configuration



3-View Diagram




GAS FILLED STRUT, ADJUSTABLE
FOOT PEDAL
FRONT HINGE
REAR HINGE
INSPECTION WINDOW
HANDRAIL
GAS FILLED STRUT, NON-ADJUSTABLE
VIEWING HOLE INDICATOR PLATE
FOLDING SUPPORT STRUT
PRESSURE SEAL
INTERNAL HANDLE
OVER CENTRE SPRING
INSPECTION WINDOW 4 PLACES
PASSENGER HAND CABLE
DOOR DRAW BOLTS 6 PLACES



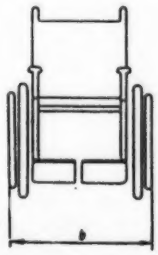
Vestibule and Aisleway Configuration

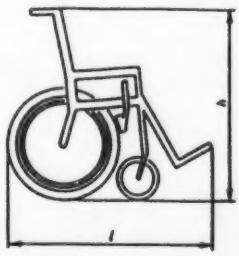
APPENDIX D:

Representative Wheelchair Dimensions

Wheelchair Dimensions

Manuf.	Model	Length l (in)	Height h (in)	Width b (in)	Folded Width (in)	Storage Volume (cub ft)	Weight (lb)
Standard Wheelchairs							
Source: Wheelchair Database - RESNA							
Scan of Everest & Jennings, Invacare, Theradyne							
Maximum Dimensions		34.5	49.5	31.9	17.5	17.3	60
Minimum Dimensions		29.5	33.2	20.5	10.5	6.0	27
E&J	Premier P8AU250-624	31.5	39.2	31.9	11.7	8.4	52
Invacare Rolls	D200 D228	31.0	36.5	25.5	11.5	7.5	43
E&J	Premier P8NULD200	30.8	36.5	22.8	10.5	6.8	30
Electric Wheelchairs							
Source: Product Literature							
Fortress Scientific	655-FS						
	overall	33.0	43.0	24.0	-	19.7	140
	seat		25.0	24.0	-		40
	power base	29.2	16.0	24.0	-	6.5	102
Invacare	Power Rolls Arrow	33.0	37.5	26.0	-	18.6	102
Scooters							
Source: Product Literature							
Electric Mobility	Rascal	39.0	34.0	21.0	-	16.1	63
Invacare	Rolls Runabout		37.0	23.5	-		85
Sports Chairs							
Source: Product Literature							
Invacare	Rolls Folding 500		30.0	23.2	14.7		
Invacare	Rolls Team 500	42.0	26.5	25.2	-	16.2	20





APPENDIX E:

Boarding and In-Flight Chairs

BOARDING AND IN-FLIGHT CHAIRS

Company	Product	Reference
ACCUTRON Tool and Instrument Co 505 Howmet Drive Hampton, VA USA 23661 (804) 838-4269	ACCUTRON ON BOARD WHEELCHAIR: • collapsible, highly maneuverable; • rigid, non-folding frame; • width 16", wight 30 lbs.; • folded dimensions: 8.5"H x 16"W x 31"D.	
Aluweld Route des Acacias, 25 1227 Acacias/Geneve Switzerland 022/43 68 77	STAIR CLIMBING TROLLEY TGR:Motorized stair climber and boarding chair: • can be operated by one person; • width 15", weight 115 lbs. • maximum loading capacity 265 lbs.	
Manufactured Products Lafayette, Louisianna U.S.A.	LE FREEWAY: Battery powered boarding chair which climbs steps • chair weighs 46-65 kg (depending on model); • has capacity of 120kg.	5
Amigo Sales International 6693 Dixie Highway Bridgeport, Maine USA 48722	AMIGO ESCORT: Boarding chair: (Now off the market) • seat can swivel and lock; • armrests may be too wide for some aircraft; • in use by United, American and KLM; • costs $685 US.	
Manten Company Limited 10-1, 1-Chome Nipponbashi-Higashi Naniwa-Ku Osaka, Japan	MANTEN AIRPORT BUGGY: Boarding chair with large rear wheels (permitting self-propulsion) which can be removed for boarding • compatible with Stair-Trac; • being used by Air Canada and Piedmont.	1
AGI 75 Rue Saint-Denis 93300 Aubervilliers France	ESCAMATIC: Battery powered stair climber (rate of 11 steps per minute): • similar to the Edrey Chair; • 3 small wheels at rear permit one person to push chair up or down stair; • two drive chains; each has 'wheeled' hooks which come around to grip steps; • one model is narrow enough to fit down aircraft aisle; weighs 52kg; • cost of 2,700 pounds sterling.	Magazine Ad
Brio AB/Brio Rehab (with Univ. of Gottenburg, Dept. of Research for the Disabled) S-28300 Osby, Sweden Tel. Int. +4647919000	TRAVEL MATE: boarding chair can be either pushed or carried; • armrests can be folded away for seat change; • long, rear carrying handles which permit rear lifter to turn and face steps; • 44 cm wide, 45 cm high, weighs 14.1 kg;	Product Literature
Brockway Air Ltd. U.S.A.	BROCKWAY AIR PROTOTYPE: Boarding chair: (experimental model) • only 11" wide, approximately 3' high; • seat too small for most passengers; • created for a Congressional Hearing in Washington, not in production.	6
Edrey Company P.O. Box 1428 Baldwin Park CA USA, 91706 (818) 960-4889	POWERLIFT STAIR CHAIR: battery powered stair climbing chair: • passenger has to be lifted manually onto the chair; • can be used with Twin Otters; • widely used in the U.S.	1
Everest & Jennings 3233 E. Mission Oaks Blvd. Camarillo, CA 93010 (805) 987-6911	HIGH DOLLY MODEL 46E: Boarding chair widely used in airline industry: • rigid, non-folding frame; • width 14.5", wight 17 lbs.; • safety straps, two large rear wheels.	

BOARDING AND IN-FLIGHT CHAIRS

Company	Product	Reference
FERNO, A Division of FERNO-WASHINGTON, Inc. 70 Weil Way Wilmington, OH 45177-9371 (513) 382-1451	TRAVELER STAIR CHAIR: • collapsible - fits into overhead luggage rack; • designed for aircraft, jetways, cruise ship gang planks; • width 15", weight 15 lbs.	
Fortress Scientific 3750 Chesswood Drive Downsview, Ontario M3J 2Wg 1-800-268-7961	AIRLINE TRANSFER CHAIR: Boarding chair (and use in some terminals): • flip arm rests; • wheel locks; • swivel seat (360° and locks into position); • 55 cm (21.5") wide, weighs 41 lbs.	7
Robert Fulton Company Platts Hill Road Newton, CT USA 06470 (202) 426-9700	WILSHIRE AID-CHAIR: Boarding chair that can be stored on board aircraft but does not have self-propulsion ability: • large rear wheels; • collapsible, detachable back; • 16" wide, weighs 28 lbs.; • used by Air Canada and Wardair.	1
Garaventa (Canada) Ltd. 7505-1344 Street Surrey, BC Canada (614) 594-0422	STAIR-TRAC: Portable, battery-operated stair climber (max. slope of 35°) • attendant moves chair along stairs; • can accommodate standard wheelchair.	Product Literature
Inovint - Einrichtungs Gmb H Holzmuhlenstrasse 84-86 D-2000 Hamurg 70 Federal Republic of Germany	I. DEE M. CHAIR: In-flight wheelchair; • double castors provide manoeuverability; • chest, lap, and foot straps; • can be folded for storage; • 40.5 cm wide, weighs 11 kg.	
Newton Products Birmingham, England	SKYCHAIR: Developed for the Spastics Society • Adopted by British Airways for all wide-bodied aircraft.	
Spastics Society England	STREAMLINER: Folding chair has large rear wheels (for self-propulsion) • which can be removed for boarding: • compatible with Combi-Stair.	1
T-Star Gmb H Arabellastrasse 5/134 D-8000 Federal Republic of Germany	VOGEL SEAT: Developed by Airbus Industrie; (now withdrawn from market) • dual brake controls, footrest; • can be folded for storage; • can be positioned and braked over toilet and seat bottom slides clear of bowl; • 40.5 cm wide, 52.5 cm high.	
TRAV-L-CHAIR Inc. 1903 Karen Lane Tallahassee, FL USA 32304	TRAV-L-CHAIR: narrow enough to traverse DC-9 aisle; • seat portion slides into aircraft seat; • passenger is never handled or transferred; • wheeled base folds down into unit size of small suitcase; • chair can be fitted with different wheels.	Product Literature

REFERENCES:

1 Barbara A. Smith, "Aircraft Boarding of Wheelchair Passengers, Phase 1: Assessment of Current Practice" March 1983.

2 W.F. McCaffrey and M.G. O'Brien, "Aircraft Boarding of Wheelchair Passengers, Phase 2: Detailed Assessment of Mechanical Boarding Devices, September 1985.

3 Dr. Michael D. O'Riain, "Novel Station-Based Boarding Device Concept for Inter-City Bus Applications" January 1987.

4 U. Rutenberg and M. Barber, "Modular Transfer Platform (SCAT 02) Outdoor Model, Prototype and Field Tests" July 1986

5 NINNESCAH, September/October, 1986.

6 NINNESCAH, November/December, 1987.

7 Airline Transport, December 1987.

8 NINNESCAH, September/October, 1984.

APPENDIX F:

Existing Level Change Equipment

EXISTING LEVEL CHANGE EQUIPMENT

Company	Product	Reference
Air Canada Airport Operations Services Place Air Canada Montreal, PQ Canada, H2Z 1X5 (514) 879-7935	FORKLIFT/PALLET: Can accommodate one wheelchair passenger: • passenger not protected from adverse weather conditions; • in use at most Canadian airports; • 1985 purchase price of $31,000. • (manufactured by Airside Systems).	2
Airside Systems Inc. P.O. Box 36 Sharon Hill, PA USA, 19079 (215) 586-4300	PLANE MATE: Mobile loading lounge: • can accommodate up to 5 wheelchairs; • size could restrict movement at airports; • if Plane Mate unable to dock at bridge, passengers can be manually lifted; • in operation at 3 Canadian airports; • 1985 purchase price of $730,000 (and costs $110/hr to operate).	2
Baker Forklifts Hansler Industries Ltd. 1385 California Avenue Brockville, ON K6V 5V5 (613) 342-4450	FORKLIFT: • Used to lift pallett device.	2
Casco Zug AG Baarerstrasse 36 6300 Zug, Switzerland 042/215656	STAIR AID: Portable, battery operated, dual-tracked device using passenger stairs: • can accommodate standard wheelchair; • 1m long makes manoeuvering at top of stairs difficult in small aircraft; • similar to Stair-Trac.	1
Dahms and Company Limited Luneburg, Germany	FOUR-FUNCTION ELEVATOR STAIRS: Stairs with built-in elevator platform: • passenger can remain in own wheelchair.	5
De Reus BV Postbus 4 2920AA Krimpen a/d Ijssel Holland 31-01807-12266	MONOCLIMBER: Electrically driven carriage with wheelchair platform resting on 2 rubber tracks; • passenger has to be lifted manually; • in use at Schiphol Airport by KLM.	1
Edbro Ltd. Lever Street Bolton, England BL3 6DJ	HI-LIFT:	2
Hastings Deering Ltd. Parramatta Road Lidcombe, N.S.W. 2141 Australia	HANDICAPPED PASSENGER LIFT: Enclosed cabin on the back of a truck which is raised using hydraulic scissor lift: • used by Quantas Airways for loading large aircraft.	1
Houle Hi-Reach Equip. Ltd. 280 Deerhide Cres, Weston, Ontario M9M 2Y6 (416) 745-1600 FAX: 745-1633	$25k per unit; 2/3 wheelchairs at a time: Gerry Hebert (Still in design stage)	Internal

EXISTING LEVEL CHANGE EQUIPMENT

Company	Product	Reference
Invaco P.O. Box 35 N-1464 Fagerstrand, Norway	COMBI STAIR: Passenger stairway with a movable electric platform (heights from 1.9 - 3.4 m): • passenger must be lifted manually; • lift platform 1.09 x 1.30 m); • prototype in use at Oslo's Fornebu Airport. • mfrd by: H.W. Edgehill Equipment, Hook, Hampshire, England	1
Mid-Canada Equipment Sales 1900 Brookside Winnipeg, Manitoba R2R 1V6 (214) 641-1700	(Still in design stage)	Internal
Robert Mitchell Inc. P.O. Box 950 St-Laurent, PQ Canada, H4L 4W5 (514) 747-2471	GALLEY SERVICE TRUCK: Enclosed cabin which can be raised on the back of a truck (height ranges from 2.1 to 2.6m): • can accommodate one wheelchair passenger; • those owned by Air Canada are equipped with a rear mechanical lift; • used at every major airport in Canada, as well as at some of the smaller ones offering scheduled flights; • 1985 purchase price of $112,000.	2
Nordskog Industries Ltd. 16216 Raymer Street Van Nuys, CA USA 91406 (213) 989-1110	INVALID PASSENGER LIFT: Enclosed cabin which can be raised on the back of a truck:	1
Norwich Coach Works Burton Road Norwich, Norfolk England Norfolk; 49221	INVALIFT: Capable of servicing all aircraft at London's Heathrow Airport: • used by British Airways.	1
Pacific Western Airlines	P.W.A. LIFT: Electric lift which is bolted to existing stairs: • platform 60" x 35", with 500 lb capacity; • designed for all-weather operation; • can be operated manually.	
SOVAM Division Aeroportuaire Route de Moncoutant B.P. 56 79200 Parthenay France	H.E.L.P.: Mobile loading lounge: • prototype in use at Nice airport.	2

EXISTING LEVEL CHANGE EQUIPMENT

Company	Product	Reference
Trepel AG D-6200 Wiesbaden Hagenauer Str. 42 Postfach 130 205 49-6121-959	LIFT-O-MOBIL: Enclosed cabin which can be raised on the back of a truck: • equipped with rear mechanical lift; • can easily manoeuver at airports; • can accommodate up to 4 wheelchairs; • one in operation in North America; • 1985 purchase price of $132,000.	2
University of Ottawa, Royal Rehabilitation Ottawa Centre 505 Smythe Road Ottawa, Ontario K1H 8M2 (613) 737-7350	SYSTEM 1: Rail type mechanism which rests on the floor and the chair rides up on it: • passenger transferred from own wheelchair to system; • prototype.	3
University of Ottawa, Royal Rehabilitation Ottawa Centre	SYSTEM 2: System involves two ramps: • wheelchair pushed up ramps by attendant; • prototype.	3
Jetway Corporation Ogden, Utah U.S.A.	JETWAY LOADING BRIDGE • telescoping loading bridge hinged at terminal building. • may load aircraft with door sill to tarmac heights as low as 5 feet. • levels at aircraft door, electrically heated, hydraulically powered. • used by Whitehorse airport.	

REFERENCES:

1 Barbara A. Smith, "Aircraft Boarding of Wheelchair Passengers, Phase 1: Assessment of Current Practice" March 1983.

2 W.F. McCaffrey and M.G. O'Brien, "Aircraft Boarding of Wheelchair Passengers, Phase 2: Detailed Assessment of Mechanical Boarding Devices, September 1985.

3 Dr. Michael D. O'Riain, "Novel Station-Based Boarding Device Concept for Inter-City Bus Applications" January 1987.

4 U. Rutenberg and M. Barber, "Modular Transfer Platform (SCAT 02) Outdoor Model, Prototype and Field Tests" July 1986.

5 NINNESCAH, November/December, 1985.

APPENDIX G:

Air Carrier and Airport Contacts

Appendix G: Contacts

Air Carrier Contacts:

o	Inter Canadian (Quebec Aviation) Quebec City, Quebec	Mr. Daniel Dionne (800) 763-4004 Mr. Daniel Lessard (514) 631-9802
o	Air B.C. Richmond, B.C.	Mr. Bill Groth (604) 273-2464
o	Air Creebec Val d'Or, Quebec	Mr. Dave Bertrand (819) 825-8355 Mr. Ivan Rasico (819) 825-8355
o	Air Ontario London, Ontario	Ms. Terry Holdinga (519) 453-8440
o	Canadian Partner Toronto, Ontario	Mr. Antony Man Son Shing (416) 675-8311

Airport Contacts:

o	Lester B. Pearson Toronto, Ontario	Mr. Bob Rapier (416) 676-3457
o	Toronto Island Toronto, Ontario	Mr. Alex Holme (416) 868-6942
o	Quinte Municipal Airport Trenton, Ontario	Mr. John Allen (613) 394-4859
o	Victoria International Sidney, B.C.	Mr. Gary Hamburg (604) 356-6600
o	Gatineau Airport Gatineau, Quebec	M. Noel (819) 663-0737
o	Penticton Airport Penticton, B.C.	Mr. Jim Warman (604) 492-6042
o	Fredericton Airport Fredericton, N.B.	Mr. John Craft (506) 446-6280

APPENDIX H:

Conceptual Design Evaluation

CONTENTS

Table H.1 Evaluation Framework: Weighting Factors for the Various Design Elements

Table H.2 Evaluation of Mobility Aid Concepts (using the Framework)

(i) Safety - 1 page
(ii) Functional Adequacy - 1 page
(iii) Technical Requirements - 2 pages
(iv) Passenger Requirements - 1 page

EXPLANATION

Table H.1 lists the various design elements and design factors which form the Evaluation Framework, as developed in Chapter 3 of the report. For each element and factor weights are assigned, which reflect their relative importance to the overall design.

Table H.2 shows the detailed evaluation of the nine design options. It includes the scores on each design factor for each option.

TABLE H.1: EVALUATION FRAMEWORK: WEIGHTING FACTORS FOR THE VARIOUS DESIGN ELEMENTS

Design Element	Design Factor	Importance as % of Each Design Element	Importance as % of Each Factor	Weighting Factors
Safety		25	100	25
	(a) Standards		20	5
	(b) Aircraft Interface		20	5
	(c) Groundside Interface		20	5
	(d) Reliability of Equipment		20	5
	(e) Passenger Protection		20	5
Functional Adequacy		25	100	25
	(a) Personnel		8	2
	(b) Time Required		12	3
	(c) Preboarding		16	4
	(d) Physically Integrated System		16	4
	(e) Portability		12	3
	(f) Number of passenger transfers		12	3
	(g) Climatic		12	3
	(h) Passenger boarding time		12	3

TABLE H.1 (Con't)

Design Element	Design Factor	Importance as % of Each Design Element	Importance as % of Each Factor	Weighting Factors
Technical Requirements		25	100	25
	(a) Standards		12	3
	(b) Flexibility		8	2
	(c) Aircraft Compatibility		12	3
	(d) Aircraft Interface		12	3
	(e) Passenger positioning and transfer to seat		8	2
	(f) Power		8	2
	(g) Manual Override		8	2
	(h) Existing Technology		8	2
	(i) Design life		8	2
	(j) Maintenance/ servicing		8	2
	(k) Control system features		8	2
Passenger Requirements		25	100	25
	(a) Exterior appearance		12	3
	(b) Passenger physical comfort		16	4
	(c) Passenger psychological comfort		16	4
	(d) Level of effort required for transfer		16	4
	(e) Ascending and descending acceleration		8	2
	(f) Vibration of passenger seat		8	2
	(g) Noise levels during operation		8	2
	(h) Climatic		16	4

TABLE N.2

EVALUATION OF MOBILITY AID CONCEPTS FOR SMALL AIRCRAFT

DESIGN ELEMENT	SUGGESTED DESIGN CRITERIA		WEIGHTING FACTOR	OPTION 1 LLL-P		OPTION 2 LLL-F
	IDEAL	MINIMUM ACCEPTABLE		Rating	Score	Rating
SAFETY						
(a) Standards		Ability to meet relevant CSA Standards CAN3-B355-M86 and CAN3-D409-M84.	5	*	0	*
(b) Aircraft Interface		Provide complete protection to aircraft during use. Self-aligning.	5	4	20	4
(c) Groundside Interface; Vehicle Safety	All safety equipment can be carried on vehicle; No potential interference with other vehicles.	No danger to users or operators.	5	6	30	5
(d) Reliability of Equipment	Simple equipment: No possibility of stranding a user.	Complex equipment: Some possibility of stranding a user over the life of the equipment.	5	9	45	9
(e) Passenger Protection	Provide complete passenger body support.	Sufficiently stabilize and restrain passengers who require upper body and/or lower body support. No exposure to moving or rotating components. No risk to passenger safety as a result of operator error.	5	8	40	9
SUB-TOTAL					135	

RATING x WEIGHTING FACTOR = SCORE

PTION 2 LLL-F		OPTION 3 Switchback		OPTION 4 Cent Elev		OPTION 5 Adj Elev		OPTION 6 StairGlide		OPTION 7 Stairamp		OPTION 8 Mini-Shuttle		OPTION 9 Forklift/Pall	
Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score
*	0	*	0	*	0	*	0	*	0	*	0	*	0	*	0
4	20	3	15	7	35	7	35	7	35	7	35	6	30	5	25
5	25	7	35	8	40	8	40	8	40	8	40	5	25	5	25
9	45	8	40	6	30	6	30	6	30	7	35	7	35	7	35
9	45	8	40	7	35	7	35	7	35	7	35	8	40	8	40
	135		130		140		140		140		145		130		125

* Not applicable at the concept level.

TABLE H.2

EVALUATION OF MOBILITY AID CONCEPTS FOR SMALL AIRCRAFT

DESIGN ELEMENT	SUGGESTED DESIGN CRITERIA		WEIGHTING FACTOR	OPTION 1 LLL-P		OPTION 2 LLL-F	
	IDEAL	MINIMUM ACCEPTABLE		Rating	Score	Rating	Score
FUNCTIONAL ADEQUACY							
(a) Personnel	Minimal effort (1 person) required to position and operate device.	Moderate (2 people).	2	3	6	3	6
	No personnel training required.	1 hour of personnel training to operate system.					
(b) Time Required	Physical deployment time of 5 minutes.	Physical deployment time of 10 minutes.	3	6	18	6	18
(c) Preboarding	Not required	Required	4	10	40	10	40
(d) Physically Integrated System	Benefits both able and disabled passengers.	Does not impede the regular flow of passenger traffic.	4	10	40	10	40
(e) Portability	Easily transported by one operator.	Can be maneouvered by two operators.	3	4	12	4	12
(f) Number of Passenger Transfers	Minimize passenger transfers to two: One inside the terminal, the other adjacent to aircraft seat.	4 transfers maximum. (Including rolling into different lifts or vehicles.)	3	10	30	10	30
(g) Climate	Be capable of operating under severe weather conditions.	Be able to function under light snow, rain and extremely cold condition Be capable of operation on snow/ice surface.	3	8	24	10	30
(h) Passenger Boarding Time	Less than 3 minutes (waiting room to aircraft vestibule.	Less than 5 minutes (waiting room to aircraft vestibule).	3	8	24	9	27
SUB-TOTAL					194		203

RATING x WEIGHTING FACTOR = SCORE

ION 2 LL-F		OPTION 3 Switchback		OPTION 4 Cont Elev		OPTION 5 Adj Elev		OPTION 6 StairGlide		OPTION 7 Stairramp		OPTION 8 Mini-Shuttle		OPTION 9 Forklift/Pall	
ting	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score
3	6	6	12	8	16	8	16	8	16	8	16	6	12	4	8
6	18	4	12	6	18	6	18	6	18	5	15	7	21	7	21
10	40	8	32	8	32	8	32	8	32	8	32	3	12	3	12
10	40	6	24	5	20	5	20	5	20	8	32	1	4	0	0
4	12	4	12	8	24	8	24	8	24	8	24	7	21	7	21
10	30	10	30	6	18	6	18	6	18	6	18	6	18	6	18
10	30	8	24	8	24	7	21	7	21	7	21	8	24	8	24
9	27	7	21	7	21	7	21	7	21	7	21	8	24	7	21
	203		167		173		170		170		179		136		125

* Not applicable at the concept level.

TABLE H.2

EVALUATION OF MOBILITY AID CONCEPTS FOR SMALL AIRCRAFT

DESIGN ELEMENT	SUGGESTED DESIGN CRITERIA		WEIGHTING FACTOR	OPTION 1 LLL-P		OPTION 2 LLL-F	
	IDEAL	MINIMUM ACCEPTABLE		Rating	Score	Rating	Score
TECHNICAL REQUIREMENTS							
(a) Standards Applicable		Ability to meet applicable CSA Standards CAN3-B355-M86 and CAN3-D409-M84.	3	*	0	*	0
(b) Flexibility	Adaptable to airports of different sizes and operating characteristics.	Useful in only small or large airports; ie. for either light or heavy loads (but not both).	2	5	10	4	8
(c) Aircraft Compatibility	Compatible with all aircraft used in scheduled service carrying 60 passengers or less.	Compatible with the 4 representative aircraft (Metroliner III, Jetstream 31, Dash 8, Twin Otter). - Minimum doorway height 116 cm (45.5 in.) - Minimum doorway width 63 cm (25 in.) - Tarmac to aircraft floor 100 cm (40 in.) to 140 cm (55 in.)	3	9	27	9	27
(d) Aircraft Interface	No intrusion into the vestibule thereby maintaining maximum space available to aircraft personnel and/or persons assisting.	Minimum intrusion into the vestibule.	3	9	27	9	27
	No modifications to aircraft to accommodate the boarding device.	Minor modifications to improve accessibility such as removable arm rests and airstair handrails.					
(e) Passenger Positioning and Transfer to Seat	Provide means to transport passenger to appropriate seating location with 11" aisle width (i.e., Twin Otter). Upon entering vestibule, allow passenger to either face the aircraft or away from the aircraft.	Provide means to transport passenger to appropriate seating location with 14 in. aisle width (i.e., Metro III).	2	9	18	9	18

RATING x WEIGHTING FACTOR = SCORE

OPTION 2 LLL-F		OPTION 3 Switchback		OPTION 4 Cent Elev		OPTION 5 Adj Elev		OPTION 6 StairGlide		OPTION 7 Stairamp		OPTION 8 Mini-Shuttle		OPTION 9 Forklift/Pall	
Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score
*	0	*	0	*	0	*	0	*	0	*	0	*	0	*	0
4	8	5	10	9	18	9	18	9	18	9	18	2	4	5	10
9	27	7	21	8	24	8	24	8	24	8	24	9	27	8	24
9	27	7	21	7	21	7	21	7	21	7	21	9	27	7	21
9	18	9	18	9	18	9	18	9	18	9	18	10	20	9	18

* Not applicable at the concept level.

TABLE H.2

EVALUATION OF MOBILITY AID CONCEPTS FOR SMALL AIRCRAFT

DESIGN ELEMENT	SUGGESTED DESIGN CRITERIA		WEIGHTING FACTOR	OPTION 1 LLL-P		OPTION 2 LLL-F	
	IDEAL	MINIMUM ACCEPTABLE		Rating	Score	Rating	Score
(f) Power	Manually powered or powered by existing groundside equipment.	Self-contained source.	2	10	20	10	20
(g) Manual Override	Device should be equipped with an easily accessible manual override system requiring minimum effort by the operator. (1 minute execution time).	Device should be equipped with an easily accessible manual override system requiring minimum effort by the operator (3 minutes execution time).	2	*	0	*	0
(h) Existing Technology	Exclusive use of standard off-the-shelf components/hardware. Use of existing technology.	Maximum use of standard off-the shelf components/hardware. Based on existing technology.	2	7	14	7	14
(i) Design Life	5000 cycles minimum.	1000 cycles minimum.	2	10	20	10	20
(j) Maintenance/ Servicing	Not required throughout design life.	Comparable to other groundside equipment. Good access to all serviceable components.	2	9	18	9	18
(k) Control System Features	Simple control system (self-evident controls positive feedback, etc.) Failsafe device - in the event of power failure (average descent speed less than 7.8 m/minute, where applicable). Standardized operating procedures under all weather conditions.		2	*	0	*	0
SUB-TOTAL					154		152

RATING x WEIGHTING FACTOR = SCORE

TION 2 LLL-F		OPTION 3 Switchback		OPTION 4 Cent Elev		OPTION 5 Adj Elev		OPTION 6 StairGlide		OPTION 7 Stairamp		OPTION 8 Mini-Shuttle		OPTION 9 Forklift/Pall	
ating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score
10	20	5	10	5	10	5	10	5	10	7	14	3	6	10	20
*	0	*	0	*	0	*	0	*	0	*	0	*	0	*	0
7	14	5	10	3	6	4	8	6	12	2	4	2	4	7	14
10	20	9	18	4	8	5	10	5	10	6	12	8	16	8	16
9	18	8	16	4	8	5	10	5	10	6	12	5	10	5	10
*	0	*	0	*	0	*	0	*	0	*	0	*	0	*	0
	152		124		113		119		123		123		114		133

* Not applicable at the concept level.

TABLE H.2

EVALUATION OF MOBILITY AID CONCEPTS FOR SMALL AIRCRAFT

DESIGN ELEMENT	SUGGESTED DESIGN CRITERIA		WEIGHTING FACTOR	OPTION 1 LLL-P		OPTION 2 LLL-F	
	IDEAL	MINIMUM ACCEPTABLE		Rating	Score	Rating	Sco
PASSENGER REQUIREMENTS							
(a) Exterior Appearance	Blends into airport architecture and aircraft environment. Integration of colours surface textures and structural components. No sharp corners or overhanging structures.	Corners or overhanging structures are mitigated.	3	7	21	7	
(b) Passenger Physical Comfort	All components of the device which physically come in contact with the passenger should be covered or padded.	Major components which come in contact with the passenger should be padded.	4	9	36	10	4
(c) Passenger Psychological Comfort	The disabled passenger will be treated in the same manner as other passengers.	The disabled passenger will not feel stigmatized or embarrassed about using the device.	4	9	36	10	4
(d) Level of Effort Required for Transfer	Minimum (unassisted).	Medium - 1 person assisting.	4	8	32	8	32
(e) Ascending and Descending Acceleration	Gradual acceleration (not to exceed 90 cm/sec/sec, ramps not to exceed 1:12 gradient).		2	10	20	10	20
(f) Vibration of Passenger Seat	No significant vibration.	Minimal vibration.	2	8	16	8	16
(g) Noise Levels During Operation	Comparable to light traffic at 15 m, may be considered intrusive (maximum 60 dB).	Comparable to light traffic at 15 m, telephone difficult to use (maximum 70 dB).	2	10	20	10	20
(h) Climatic	Provide complete passenger protection from the elements (comperable to jetways).	No risk of injury as a result of exposure to the elements (comparable to current passenger protection).	4	8	32	10	40 0
SUB-TOTAL					213		229
TOTAL					696		719

RATING x WEIGHTING FACTOR = SCORE

N 2 -F		OPTION 3 Switchback		OPTION 4 Cent Elev		OPTION 5 Adj Elev		OPTION 6 StairGlide		OPTION 7 Stairamp		OPTION 8 Mini-Shuttle		OPTION 9 Forklift/Pall	
ng	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score
7	21	5	15	6	18	6	18	6	18	6	18	8	24	3	9
10	40	6	24	7	28	7	28	7	28	7	28	7	28	5	20
10	40	8	32	7	28	8	32	8	32	6	24	5	20	2	8
8	32	8	32	6	24	6	24	6	24	6	24	6	24	6	24
10	20	10	20	9	18	9	18	9	18	9	18	9	18	9	18
8	16	6	12	4	8	4	8	4	8	6	12	4	8	2	4
10	20	9	18	5	10	5	10	5	10	7	14	7	14	2	4
10	40	5	20	8	32	5	20	5	20	5	20	10	40	5	20
	0		0		0		0		0		0		0		0
	229		173		166		158		158		158		176		107
	719		594		592		587		591		605		556		490

* Not applicable at the concept level.

APPENDIX I:

Project Review Committee

PROJECT REVIEW COMMITTEE

Ms. Valerie Dufour
Director
Domestic Air Policy
Transport Canada (ACEB)
Tower "C"
Place de Ville
Ottawa, ONT.
K1A 0N5
(613) 991-6435

Mr. Stephen Little
Manager of Community Initiatives
Office for Disabled Persons
700 Bay St.
16th. Floor
Toronto, ONT.
M5G 1Z6
(416) 963-3121

Mr. Stuart T. Grant
Vice-President & Secretary
Air Transportation Association of Canada
99 Bank St.
Ottawa, ONT.
K1P 6B9
(613) 233-7727

Mr. Ellis Reida
Editor, NINNESCAH
P.O. Box 1434
Grand Central Station
New York, N.Y.
USA 10163
(718) 446-5815

Ms. Diana Kirkpatrick
Vice-President
Regional Airline Association
1101 Connecticut Avenue, N.W.
Washington, D.C.
USA 20036
(202) 857-1170

Ms. Linda Landry
Director
Transportation Services for Disabled Persons
Dispute Resolution Agency
Ottawa, ONT.
K1A 0N9
(613) 997-6829

Mr. Frank Hare
Chief, National Programs
Airports Operations Requirements
Airports Operations
Airports Authority Group
Transport Canada (AKOCC)
20D, Tower "C"
Place de Ville
Ottawa, ONT.
K1A 0N8
(613) 990-3735

Ms. Marie Doll
Manager, Passenger Safety
Operations and Certification
Aviation Regulation
Aviation Group
Transport Canada
200 Kent St. (6C)
Ottawa, ONT.
K2P 2J8
(613) 990-1048

Ms. Barbara Smith
Program Officer, Special Needs
Transportation Development Centre
Guy-Favreau Complex
200 Dorchester Blvd. West
Suite 601, West Tower
Montreal, P.Q.
H2Z 1X4
(514) 283-0020

Mr. Roy Nishizaki
Project Officer
Transportation Development Centre
Guy-Favreau Complex
200 Dorchester Blvd. West
Suite 601, West Tower
Montreal, P.Q.
H2Z 1X4
(514) 283-0020

Mr. Jack Swann
Manager, Furnishings Design
DeHavilland Aircraft of Canada
Garratt Blvd.
Downsview, ONT.
M3K 1Y5
(416) 633-7310